OE FORM 6000, 2/69

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF EDUCATION

ERIC REPORT RESUME

ERIC ACC. NO.				
ED 035 776				
CH ACC. NO.	P.A.	PUBL. DATE	ISSUE	
AA 000 479		Mar 70	RIEJUN70	

IS DOCUMENT COPYRIGHTED? YES ☐ NO ☒
ERIC REPRODUCTION RELEASE? YES ☐ NO ☒
LEVEL OF AVAILABILITY I ☒ II ☐ III ☐

AUTHOR

TITLE
Science and Math Education Information Report: National Association for Research in Science Teaching. 43rd Annual Meeting. Abstracts of Presented Papers.

SOURCE CODE	INSTITUTION (SOURCE)
RUF67410	Ohio State University, Columbus, ERIC Information Analysis Center for Science Education
SP. AG. CODE	SPONSORING AGENCY

EDRS PRICE	CONTRACT NO.	GRANT NO.
1.00;11.85		

REPORT NO.	BUREAU NO.

AVAILABILITY

JOURNAL CITATION

DESCRIPTIVE NOTE
235p.

DESCRIPTORS

Abstracts; *Conference Reports; Curriculum; *College Science; *Elementary School Science; *Research Projects; *Science Education; *Secondary School Science; Teacher Education

IDENTIFIERS

ABSTRACT
This report contains abstracts of most of the research papers in science education presented at the 43rd annual meeting of the National Association for Research in Science Teaching in Minneapolis, Minnesota, March 5-8, 1970. Also included are the topics and names of participants of several symposia at the conference. The abstracts are organized under topic headings corresponding to the various sessions. Among the wide range of subjects covered are the Gagne learning model, Piaget based learning studies, student achievement and attitude assessment in science, instructional variables and techniques, curriculum organization, curriculum evaluation models, science instruction in the elementary and junior high schools, teacher education in science, Earth Science Curriculum Project research and the career development of science teachers. Each abstract contains the procedures, findings and conclusions of the study. In some abstracts, the experimental designs and null hypotheses are included. This report is intended for science education researchers, science teachers and school administrators. (LC)

NATIONAL ASSOCIATION

FOR RESEARCH IN SCIENCE TEACHING

43rd ANNUAL MEETING

ABSTRACTS OF PRESENTED PAPERS

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NATIONAL ASSOCIATION

FOR RESEARCH IN SCIENCE TEACHING

43rd ANNUAL MEETING

ABSTRACTS OF PRESENTED PAPERS

Leamington Hotel
Minneapolis, Minnesota
March 5-8, 1970

PREFACE

The ERIC Information Analysis Center for Science Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Minneapolis, Minnesota, March 5 through March 8, 1970.

All persons who had papers accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC Staff to provide a general format for the abstracts. Special recognition should be given to Dr. Paul DeHart Hurd who organized the program and obtained the abstracts and to Dr. Stanley Helgeson, Mrs. Maxine Weingarth, Mr. Richard Sagness, Mrs. Cheryl Brosey, Mrs. Cassandra Balthaser, and Susan Hedger who were responsible for compiling and preparing the report.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Research in Education and other publications of the ERIC system. Papers may also be requested from the authors while their limited supplies are available.

February, 1970

Robert W. Howe
Director
ERIC Information Analysis
Center for Science and
Mathematics

Sponsored by the Educational Resources Information Center of the United States Office of Education and The Ohio State University.

This publication was prepared pursuant to a contract with the Office of Education, United States Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official Office of Education position or policy.

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2. "Five Stages of Instruction for Sequencing Science Activities According to Gagné's Learning Model," Doris A. Trojcak, University of Missouri, St. Louis, Missouri.
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HIERARCHICAL ANALYSIS OF THE RANDOMIZED MULTIPLE CHOICE FORMAT

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Geneseo, N.Y.

The Randomized Multiple Choice (RMC) format was developed to allow for partial credit on machine grading of problem solutions on physics tests. This format consisted of the statement of the problem followed by five or more multiple choice items which corresponded to steps in the written solution of the problem. These multiple choice items had a random order and not the order in which the steps would occur in a written solution. This was to require the students to organize and use sequences of physical and mathematical concepts similar to the sequences used in the solution of the problem in free-response form.

Each application of a physical concept in a problem solution could be thought of as a step in the solution. The logically determined sequences of steps necessary to solve the problem were organized into a hierarchy. Each RMC item corresponded to a step in the written solution to a free-response problem. Therefore, the hierarchy of RMC items would be theoretically the same as the hierarchy of steps. If the physical concepts and the sequences in which these concepts are used are the same on both test formats then it is very probable that solving the RMC problems required the same mental skills and procedures as solving the same problems in free-response form.

Two methods of hierarchical analyses were used to determine whether the responses to the RMC items validated the theoretical hierarchy which was derived from the written solution. A consistency ratio method, similar to that used by Gagne, was used to quantitatively assess the transfer relationships for each set of dependency relationships in the hierarchies of RMC items. The pattern analysis technique developed by Rimoldi and Grib was used to analyze responses for the complete hierarchy on a subject-by-subject basis.

Data were collected on six RMC given to a sample of 170 introductory physics students.

The consistency ratios ranged from 0.73 to 0.99 with an average of 0.88. The indices of agreement, which were obtained from the pattern analysis, indicated that there was a correlation of approximately 0.78 between the expected and observed response patterns. These results indicated that the students used sequences of mathematical and physical concepts very similar to the sequences they would have used if the problems had been presented in free-response form. It was concluded that in general the same problem-solving skills and procedures were used on the RMC and free-response problems.

[1]This research was done at Purdue University

This study revealed that the RMC format, in terms of measurement of the usage of concepts and mental skills, is probably an adequate substitute for free-response problem tests currently used in college physics courses. The RMC format, which can be graded by readily available machines, would save many man hours of laborious grading time -- time which could be better spent in providing additional instruction for students.

FIVE STAGES OF INSTRUCTION FOR SEQUENCING SCIENCE ACTIVITIES ACCORDING TO GAGNE'S LEARNING MODEL

Doris A. Trojcak
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St. Louis, Missouri

Prospective teachers frequently lack confidence in their ability to sequence science lessons effectively. The major purpose of this study was to analyze the effects of five stages of instruction on pre-service teachers' ability to construct programmed science activities for fourth graders concerning ten principles of friction.

The population used in this investigation consisted of 91 undergraduates enrolled in three sections of a science methods course for elementary school teachers. One section of 36 methods students was used as a control group; two sections totaling 55 students were used as five experimental groups. The programmed lessons on friction developed by the methods students were administered to 275 fourth graders from 17 classrooms in a midwestern school system.

Each of the five experimental groups of methods students received progressively more materials and instruction on sequencing science activities. At the end of each stage of instruction, the methods students from each group were given the same assignment: to develop a programmed lesson on friction suitable for instructing an average fourth grader. Two procedures were used to evaluate these programs: (1) two judges used a criterion checklist developed by the investigator on Gagne's cumulative learning model to determine the degree of agreement between the instructional model and the programs; (2) the programs and an achievement posttest on friction were administered to five experimental groups of 275 fourth graders. (A control group of 118 fourth graders received only the posttest.) A posttest designed to measure prospective teachers' ability to sequence objectives from a fourth grade lesson on heat conduction was administered to the control group of methods students and to each succeeding experimental group upon completion of the assignment.

The application of a t test, analysis of variance, and a multiple range test enabled recognition of the following conclusions:

1. The programs from Group 4 yielded significantly higher results than those from Group 1 while programs from Group 5 were superior to all others as measured by the criterion checklist.

2. The fourth graders' posttest scores were highly correlated with the methods students' criterion checklist scores.

3. The highly significant interjudge reliability indicated that the checklist could be used objectively.

4. Each of the five succeeding experimental groups of fourth graders scored progressively higher on the posttest than the experimental group; Group 5 scored significantly higher.

5. All five experimental groups of methods students demonstrated higher performance on the sequencing posttest than the control group.

6. The amount of time the methods students spent on preparing their programs influenced the fourth graders' posttest scores irrespective of the stage of instruction received.

The educational importance of this research can be derived from the following implications:

1. Experiences in evaluating and improving poor programs as well as the opportunity to perform developmental testing of one's own program facilitated prospective teachers in preparing more effective instructional programs.

2. The program scores from the criterion checklist are predictive of the learners' performance on the posttest and therefore could be used to determine the value of the program if developmental testing were not feasible.

3. The data on the amount of time spent on preparing the programs evidenced an inverse relationship trend; that is, as more instruction was received, the time spent in preparation became less influential.

4. Methods students are capable of developing effective instructional programs with a minimal amount of instruction. Of the five stages of instruction utilized in this investigation, Stage 5 has the most potential in effecting greatest learning.

THE DEVELOPMENT OF A HIERARCHY

FOR THE LEARNING OF DENSITY PRINCIPLES

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The University of Houston
Houston, Texas

This study was designed to determine a propitious hierarchy of abilities which are prerequisite to the learning and application of the related principles of density and specific gravity. The prime focus of the study was the validation of a theoretical learning hierarchy for density and specific gravity.

The development of this psychological hierarchy consisted of three fundamental phases. First, a logical hierarchy was constructed by analysis of a terminal behavior and its components. The terminal behavior used in this study was the child's ability to predict whether an object will float when placed in a liquid, when both materials were unfamilar to the subject. Second, the hierarchy was validated through the administration of tests and the analysis of test results. Finally, the logical hierarchy was corrected using the test results to reorder, rearrange, and insert additional sets wherever needed.

Each student behavior in the hierarchy, including the terminal behavior, was evaluated by a test designed to determine if the subject possessed the behavior. Terminal behaviors were measured with an investigator-constructed transfer test which requires application of the density principle to novel situations. Relevant basic abilities were measured with standardized tests. In addition, individually administered performance tests were used to evaluate students' psychomotor skills (e.g. ability to weigh objects, determine volume of liquids). The sample included 150 students ranging from eight years of age to 18 years of age.

Results of the hierarchy development should shed considerable light on the teaching of this complex subject of density to students at all levels of instruction.

AN INVESTIGATION OF THE RELATIONSHIP OF GAGNE'S HIERARCHICAL SEQUENCE MODEL IN MATHEMATICS TO THE LEARNING OF HIGH SCHOOL PHYSICS

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Cook County School District # 212
Franklin Park, Illinois

A problem in the learning of physics may be the absence of lower level mathematical skills of the nature of those proposed in the model of Gagne. If the set of skills emphasized in mathematics differed from those used in physics, the problem-solving process in physics would represent a unique situation for the learner. Identification of, and specific remediation in, these skills should cause a significant gain in the learning of physics.

A problem-oriented card program was constructed to teach Unit II of the PSSC Course in Physics. The program was used to diagnose areas of difficulty in problem-solving. Problems occurring on 87 cards were arranged according to the hierarchies of mathematical skills required for their solution. When a student missed a problem each requisite ability was tallied as "absent". If a problem was correctly solved each requisite ability was tallied as "present". Remediation decisions were made at three points in the ten week unit based on the percent of "absent" tallies for a particular mathematical ability. Remediation was accomplished by inserting remedial card sequences into the student programmed materials for each mathematical ability judged deficient.

Of 163 mathematical abilities identified as requisite in one or more of the 87 problems chosen, all but 52 were rejected from consideration for insufficient occurrence to allow remediation decisions, or, for other reasons. The procedures outlined were then applied to two different ability level classes of physics students. Experimental and control groups were selected randomly within each class.

The programmed instruction increased student performance on the PSSC tests ($p < 0.0005$) and produced gains on the Watson-Glaser Critical Thinking Appraisal ($p < 0.005$). However, no evidence was found to suggest that mathematical remediation had improved the performance of the experimental group on the PSSC tests.

Examination of student records indicated poor diagnosis of mathematical deficiency had occurred. To determine whether the indirect method of assessing mathematical deficiency was practicable in view of the confounding of tallies several different tests were run on categorized "patterns" of tallies in the student records. Patterns of student performance defined were: no change; inconsistent with meaningful interpretation; incidental learning evidenced; and not enough data for categorization. Five chi-square tests showed consistent, significant ($p < 0.001$) deviations from chance results with the "inconsistent" category always significantly low. The correlation matrix of the numbers of each category of tally pattern in each student record was of the form predicted by educational interpretation of the tally patterns in the data (p to < 0.0005). Finally, the student tally patterns were judged to have some validity since they increased the predictability of mathematical deficiency by 50 percent over the criteria used. It was concluded that the indirect assessment of mathematical deficiency was feasible. Furthermore, analysis of tally patterns disclosed that incidental learning was four times as important a source of mathematical remediation as the procedures described. Additional research is needed to determine if this incidental learning of mathematical abilities is common to all physics instruction and how it may be promoted.

THE USE OF HIERARCHICAL ANALYSIS IN DEVELOPING AND INDIVIDUALIZING INSTRUCTION

James R. Okey
University of California
Santa Barbara, California

In order to develop validated instructional materials or to individualize instruction, similar kinds of data are needed. When developing materials, one needs to find out which of the draft materials fail to promote learning. In order to individualize instruction, one needs to find out what each student can and cannot do. Both kinds of information are obtainable from student performance on tasks in a learning hierarchy. Such a learning hierarchy shows all intellectual skills to be achieved in an instructional program. It represents, therefore, a series of hypotheses about the number, kind, and sequential relationship of intellectual skills to be achieved in an effective plan of instruction.

The study described here was carried out to demonstrate the utility of using student performance on hierarchy tasks in an instructional development effort. A second purpose was to explore procedures for obtaining information on individual student performance.

Students from five chemistry classes were randomly assigned to two treatment groups. Group 1 studied the initial version of a self instructional program and Group 2 studied a revised version. The data to guide the revision came from performance scores by Group 1 on the intellectual skills in a learning hierarchy. The hierarchy was derived by analyzing the terminal skill which the initial program was designed to teach into a sequence of subordinate intellectual skills.

By obtaining student performace for Group 1 on the hierarchy tasks following instruction, it was possible to determine precisely which tasks were failed by many students. The revision effort was carried out, guided by these findings, in an attempt to remedy specific deficiencies. Group 2 then studied the revised program followed by tests on all hierarchy tasks.

Performance on both the terminal task and the subordinate intellectial skills was significantly higher for students using the revised program (Group 2). This finding supported the major prediction of the study.

Less specific findings are available with regard to the use of a learning hierarchy in individualizing instruction. Instruction was individualized in this study and specific information was obtained about the tasks passed or failed by each student. However, nothing was done about the identified deficiencies of any individual except to inform each student of the tasks in the learning hierarchy and his individual performance on each one.

The implications of this study are straightforward. By obtaining student performance on the tasks in a learning hierarchy, precise information can be obtained to guide the revision process. Such a procedure should be particularly helpful when used in addition to other means of obtaining revision information such as teacher feedback and the opinion of subject-matter experts. The same data used in course revision can serve the purpose of guiding the efforts of individuals who fail any tasks in a learning hierarchy. Although the results of following this latter course of action were not obtained in this study, the procedure for doing so was developed.

Session I-b Experimental Studies on Science Teaching

Chairman: Stanley Norris, University of Calgary, Calgary, Canada

1. "The Effect of Laboratory Procedures and Ability Grouping on Achievement in an Introductory Chemistry Laboratory: A Preliminary Study," Richard B. Kent, De Anza College, Cupertino, California.

2. "A Comparison of Teaching Techniques in Secondary School Chemistry," Dolores B. Kurek, St. Ursula Academy, Toledo, Ohio, and Robert R. Buell, The University of Toledo, Toledo, Ohio.

3. "Development and Evaluation of a Method of Structuring Inquiry Films to Elicit Hypotheses from High School Chemistry Students," Robert Halcomb Barker, The University of Texas, Austin, Texas.

4. "Treating Chemical Equilibrium Mathematically in Secondary Schools: A Preliminary Investigation," James B. Case, The University of Nevada, Las Vegas, Nevada.

5. "An Experimental Comparison of Case Histories with Conventional Materials in Teaching a College General Education Course in Science," Donald G. Peterson, Saint Cloud State College, Saint Cloud, Minnesota.

6. "A Consideration of Direct and Indirect Teaching Styles with Respect to Achievement and Retention of Learning in Science Classes," Morton L. Wolfson, North Babylon High School, New York.

THE EFFECT OF LABORATORY PROCEDURE AND ABILITY GROUPING ON ACHIEVEMENT IN AN INTRODUCTORY CHEMISTRY LABORATORY:

Preliminary Study

Richard B. Kent
De Anza College
Cupertino, California

Can students grasp more introductory college chemistry if they have fewer laboratory set-ups to make (i.e., can one set-up be used to discover several principles and cut down on the manipulation factor?) and thus have more laboratory time to focus on the chemistry involved? This study was designed with a three-fold purpose in mind: to determine if (i) replication of an experiment in an introductory chemistry course, to focus on different concepts, might enhance the learning of these selected concepts; (ii) grouping students by ability might affect the learning of these concepts; and (iii) there be any interaction between laboratory procedure and ability grouping which might affect learning of science concepts.

Two laboratory sections containing a total of thirty-six students (no previous courses in chemistry) were selected for this study. During the study all subjects were taking an introductory course in chemistry at De Anza College in Cupertino, California. Due to scheduling difficulties it was impossible to randomly assign students to experimental or control sections. Therefore, four measures were selected to test for homogeneity of sections. These measures were as follows: the Test on Understanding Science, Form W; Thinking Introversion and Theoretical Orientation tests from Omnibus Personality Inventory, Form D; and ACT composite scores. The t test was used to test for significant differences in section means on each of these measures and none was noted (.05 level).

Upon establishing that members of the two laboratory sections could have been randomly distributed from the same population, a total of four experiments was performed by all students over a period of four weeks. The experiments done by the experimental section were written by the investigator and designed to illustrate the following chemical principles: conservation of mass, definite composition of compounds, use of a catalyst, and mass-volume relationship of a gaseous substance. The innovation in said experiments was that they featured the same experiment basically, the same apparatus, the same assemblage directions, and the same procedure but each time the experiment was performed a different aspect was emphasized. The control group performed four experiments featuring little, if any, replication of experimental apparatus, directions, reaction, etc. However, these experiments were selected from current laboratory manuals and may be used to demonstrate the same chemical principles.

Upon completing the four experiments, all students took an examination (written by the investigator) which purported to measure achievement in interpretation of laboratory data, interpretation of theory, and the combination of both. In addition, all students were again given the Test on Understanding Science.

With each of the two sections divided into high, medium, and low ability groups on the basis of their ACT scores, adjustments were made for equal frequencies in each cell and analyses of variance (ANOVA) performed on the interpretation of theory and laboratory data scores as well as on the combined scores. A t test was used to test for significant differences between sections on the post-TOUS scores.

The investigator was unable to demonstrate a significant difference in achievement means due to method of instruction. Significant differences in achievement (.05 level) were noted in all three analyses due to the effect of ability. A significant difference in achievement (.20 level) was noted on the combined achievement scores due to interaction of ability and method. A significant difference (.05 level) was noted on the interpretation of laboratory data means due to interaction of ability and method. The experimental section achieved significantly higher scores on TOUS after completing the series of experiments (.20 level).

The investigator was unable to demonstrate any superiority in achievement in laboratory due to method of instruction. However, it appears that replication of an experiment several times would be as effective in terms of student achievement, as performing a series of different chemical experiments designed to illustrate the same principles. This could reduce the cost of operating an introductory chemistry laboratory.

The possibility that replication of an experiment several times will lead to a better understanding of science is one that suggests further studies be made in this area.

The interaction noted between method and ability also warrants further investigation. The sample used for this study was small and fairly homogeneous in terms of ability.

A COMPARISON OF TEACHING TECHNIQUES IN CHEMISTRY

Dolores B. Kurek
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Toledo, Ohio

and

Robert R. Buell
The University of Toledo
Toledo, Ohio

This comparative study of teaching techniques in high school chemistry was initiated seven years ago, in a private academy located in Toledo, Ohio. The participating subjects were females of ages 16 to 18 and in grade levels 11 and 12. Eighteen subgroups were involved; the total population was 407. Two control groups were compared with 15 experimental groups for the study of two well defined areas--pedagogical and sociological strategies for teaching high school chemistry.

The questions which were raised in this investigation concerned the effective teaching and learning of chemistry with variations in (1) class size, (2) class duration, (3) laboratory, lecture, and miscellaneous teaching methods, (4) classroom behavior of the teacher, (5) sociometric seating and working assignments, and (6) instructional materials, students' I.Q., pretest scores, posttest scores, and final grade were other variables.

Formal statistical questions were concerned with the correlations between two dependent variables, posttest scores and the teacher's final estimate of achievement, and ten independent variables, some of which were tested more than once. Also considered were the correlations between the two dependent variables. Essentially two statistical techniques were employed: analysis of covariance and analysis of multiple regression data by computer. The project consisted of pretesting the students, applying the independent variables in various class organizational patterns in the subgroups, and then comparing the results obtained by means of a posttest and the teacher-assigned final grade. Student surveys of negative teaching behaviors were administered to determine their effect on learning, and sociograms were employed to assign seating and working space.

It was found that class size was only slightly significant by multiple regression analysis. Class duration had little or no effect on the achievement of students. I.Q. laboratory teaching methods, and sociometry, in that order, were the variables which bore most powerfully on achievement in high school chemistry, as measured by the instruments employed in this investigation. Additional findings were that the learning of high school chemistry was more efficient when seating and working arrangements were established from sociometric data, that the exhibition of negative teaching behaviors did not significantly affect

learning and that physical devices and materials were not related to a large degree to learning. The two dependent variables were both highly correlated with laboratory teaching procedures, sociometry, and I.Q., and were also highly correlated with each other.

ANALYSIS OF DATA SUMMARY OF COMPUTER PROGRAM
CHEM 1: POST-TEST SCORES VERSUS
ALL INDEPENDENT VARIABLES

Variable entered	Code No.	Multiple R	Standard error of estimate	F value
I.Q.	2	0.6435	10.1084	11.2343
Lab	6	0.7024	9.6951	2.3931
Social	11	0.8553	7.3040	12.4288
Misc.	8	0.8760	7.0553	2.0043
Lecture	7	0.8893	6.9632	1.3461
Neg.	10	0.9211	6.1908	4.1811
Pre T	3	0.9232	6.4127	0.2519
Size	4	0.9269	6.5990	0.4434
Time	5	0.9280	6.9486	0.1170
Mtrl.	9	. . .	. . .	0.0000

ANALYSIS OF DATA SUMMARY OF COMPUTER PROGRAM
CHEM 2: FINAL GRADS VERSUS ALL
INDEPENDENT VARIABLES

Variable entered	Code No.	Multiple R	Standard error of estimate	F value
I.Q.	2	0.7233	1.6461	17.5524
Lab	6	0.8017	1.4716	5.0206
Social	11	0.8619	1.2923	5.4494
Time	5	0.8724	1.2927	0.9923
Lecture	7	0.8814	1.3000	0.8541
Misc.	8	0.8882	1.3211	0.6196
Pre T	3	0.8909	1.3697	0.2327
Size	4	0.8956	1.4137	0.3881
Neg.	10	0.8959	1.4974	0.0222
Mtrl.	9	. . .	. . .	0 0000

The variables are listed in the sequence in which they were entered into the regression equation, and thus the listing represents the correlation with the dependent variable in decreasing magnitude.

DEVELOPMENT AND EVALUATION OF A METHOD OF STRUCTURING INQUIRY FILMS TO ELICIT HYPOTHESES FROM HIGH SCHOOL CHEMISTRY STUDENTS

Robert Halcomb Barker
The University of Texas
Austin, Texas

The purpose of this study was to develop and evaluate four single topic film loops and corresponding teacher guides for use in high school chemistry. The objective of each film was to elicit the construction of hypotheses to explain chemical phenomena.

The films were evaluated using one hundred high school chemistry students in six classes; two in each of three different schools. A sequence of four films was shown to all students. The design of the study allowed for difference in the difficulty level of the films.

Two hypotheses were constructed by students as they viewed each film presentation. The first hypothesis was constructed immediately following the film display of a chemical phenomenon which presented a problem or posed a question. The students were then shown on film some experimental evidence related to the original phenomenon and a second revised or modified hypothesis elicited.

Null hypotheses tested in the evaluation were:

1. A sample population of high school chemistry students cannot construct relevant hypotheses to explain chemical phenomena presented visually by film.

2. There is no significant difference between the scores of the initial hypotheses and the revised or modified hypotheses constructed by the sample population viewing each film presentation.

3. There is no significant difference between the scores of the constructed hypotheses based upon the original phenomena presented in the first film and the fourth film of the sequence shown.

4. There is no significant difference between the scores of the revised or modified hypotheses based upon experimental evidence presented in the first film and the revised or modified hypotheses based upon the experimental evidence presented in the fourth film of the sequence shown.

The results of the evaluation indicated:

1. Approximately sixty percent of the high school chemistry students who participated in this study could construct relevant or partially relevant hypotheses when first presented with chemical phenomena in the manner described in this study.

2. The relevancy of the revised or modified hypotheses for each film was significantly greater than the original hypotheses. This indicated that the presentation of related evidence to a problem aided in the formulation of an hypothesis concerning that problem.

3. The relevancy of the original hypothesis on the fourth film shown was significantly greater than that on the first film. This indicated an improvement in the ability to construct hypotheses with increased experience with the films.

4. There was significant improvement in the ability to construct revised hypotheses from the first film to the fourth film. This indicates an improvement of the ability of students to relate experimental evidence to the solution of a problem.

TREATING CHEMICAL EQUILIBRIUM MATHEMATICALLY IN SECONDARY SCHOOLS: A PRELIMINARY INVESTIGATION

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Las Vegas, Nevada

The current trend toward the process approach in science teaching at all levels of education, from the elementary school to the graduate school, has not yet been extended to include all the major conceptual schemes of science. In view of this situation, an in-depth study was carried out at the secondary school level, which involved the teaching of chemical equilibrium from a mathematically based author-developed teaching unit that was derived from the standard thermodynamic treatment of chemical equilibrium. This study was intended to be descriptive in nature, and its purpose was: (1) to determine whether or not the secondary school chemistry student could grasp this type of quantitative approach to teaching chemical equilibrium; and (2) to describe the characteristics of those students who were successful (by the author's standards) in grasping the topic of chemical equilibrium as presented.

An entire secondary school chemistry student population participated in this study for a period of seven school days. The mathematically based author-developed teaching unit on chemical equilibrium was divided into six lessons, and one lesson was presented by the author each day for a period of six days. At the close of the presentation of each daily lesson an eight to ten item multiple-choice test over the daily lesson was administered to the students. This test was graded immediately, and the students were informed of their performance before leaving for their next class. On the seventh and final day of the study a thirty-item multiple-choice test over the entire unit was administered to each student.

The data collected from the student's performance on each of the six daily lesson tests were used as a measure of the student's progress through the unit, and the total score for these six daily tests was used as a measure of the student's understanding of the topic of chemical equilibrium as presented. The student's performance on the final test over the entire unit was used as a measure of the student's grasp of the unit as a whole, and as a measure of his retention of the material presented in the unit. Finally, the student's performance on twelve items selected from the six daily lesson tests was used as a measure of the student's grasp of important concepts concerning chemical equilibrium as presented.

The chemistry student population was described in terms of intelligence quotient and course grades earned in general science, biology, chemistry, first-year algebra (Algebra I), plane geometry, and second-year algebra (Algebra II). Using these data, and the data collected from the above described tests, the secondary school chemistry student population studied was divided into subgroups based upon the following: (1) years of mathematics training; (2) mathematics course grades; (3) science course grades; and (4) performance on the twelve selected daily test items.

The results of the study indicate that the secondary school chemistry student who participated in this study and who was successful in grasping the mathematical approach to chemical equilibrium as presented by the author, generally had the following characteristics: an intelligence quotient of one to two standard deviations above the mean of the population; more than five semesters of mathematics background, including first-year algebra, plane geometry, and second-year algebra; more than five semesters of science background, including general science, biology, and chemistry; and his level of performance in the preceding courses was generally of high enough quality to place him in the upper twenty percent of the chemistry student population in these courses. The unsuccessful student in this study was found not to have all the above characteristics.

In view of the results obtained in this study, it is recommended that future studies employing this type of quantitative approach to teaching chemical equilibrium to the secondary school chemistry student should not attempt to reach the entire chemistry student population, but instead should be aimed at approximately the top twenty percent of the mathematics and science students in the chemistry student population. In addition, this segment of the chemistry student population should have not less than five semesters each of science and mathematics background. Also, since this study has shown that this type of quantitative approach to teaching chemical equilibrium can be grasped by the upper twenty percent (based on course grades) of the science and mathematics students in a given chemistry student population, future work in this area should attempt to be more precise and quantitatively definitive with respect to the secondary student's mathematics and science abilities. This can be accomplished through the use of the appropriate standardized tests, and would allow the results obtained to be generalized to other secondary school populations. Finally, more time should be allowed for teaching a mathematically based approach to chemical equilibrium than for the qualitative approaches currently in use in the majority of the secondary schools.

AN EXPERIMENTAL COMPARISON OF CASE HISTORIES WITH CONVENTIONAL MATERIALS IN TEACHING A COLLEGE GENERAL EDUCATION COURSE IN SCIENCE

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Saint Cloud State College
Saint Cloud, Minnesota

This study was an experimental evaluation of the merits of a case history and a current reading materials approach to a college general education science course with regard to facts and generalizations, methods of science, and scientific attitudes examination scores.

In the experimental treatment, the nature of science and scientific research and other course content were presented through case histories while in the control treatment scientific facts and generalizations were presented through semipopular current readings. The course content in both treatments centered on atomic-molecular concepts. Both treatments utilized lecture-discussions. Students were randomly assigned to treatments from the enrollment in the Temple University, three credit course, "Science and Civilization." A 1957 fall semester trial run was followed by experiments in the spring and fall semesters of 1958. Experimental class sizes were 20, 38 and 38 respectively.

Three tests were developed and used as pretests and as posttests: Scientific Information (TSI), Test of Scientific Methods (TSM), and Test of Scientific Attitudes (TSA). The test-retest product-moment correlations for these examinations as pretests given one week apart produced reliability coefficients of .74, .56, .77 respectively. As posttests the values were .91, .75, .80 respectively.

Null hypotheses relating to pre versus posttest means and variances for each examination, and for pre and posttest means and variances between treatment groups for each examination were tested.

Differences between variances (F tests) and means (t tests) of treatment groups for pretests were not significant.

Pre to posttest gains of means were found by t tests to be significant in the following instances: all groups on the TSI (.0005 level); on the TSM, experimental groups (spring, .005; fall, .0005 levels) and the fall control group (.0005 level); on the TSA, experimental groups (spring, .01; and fall, .0005 levels).

A two-way analysis of covariance was carried out with three IQ levels and pretest adjustment of posttest data. Assumptions were satisfied except for rejection of the assumption of equility of regression

coefficients on the TSI data from the fall, 1958 experiment. Further analysis showed that rejection to be associated with a significant (.05 level) superiority of the middle IQ control subgroup over the middle IQ experimental subgroup. Analysis of TSI data indicated that for the control groups mean achievement was significantly (.05 level) higher than that of the corresponding experimental groups. Analysis of TSM data indicated that the experimental group was superior to the control group at the .10 level in the spring, 1958 experiment. Analysis of TSA data indicated that the experimental group was superior to the control group at the .05 level in the fall, 1958 experiment.

The evidence favors the idea that the use of scientific case histories can enhance the teaching of science at the college level in those areas of achievement referred to as the process or methods of science and attitudes of science. These areas are also among those said to be most important to science education, both by concerned natural scientists and by science educators.

A CONSIDERATION OF DIRECT AND INDIRECT TEACHING STYLES WITH RESPECT TO ACHIEVEMENT AND RETENTION OF LEARNING IN SCIENCE CLASSES

Morton L. Wolfson
North Babylon High School
North Babylon, New York

The problem of this study was to determine the relation between the I/D ratio for selected senior high school teachers of chemistry and junior high school teachers of general science and the subsequent retention of learning by their students four months after having completed the course of study.

Three general areas have been measured: the first was the determination of the I/D ratio according to Flanders Interaction Analysis, of four chemistry teachers who taught 200 eleventh grade students in a team-teaching program in academic chemistry (in New York State the college preparatory or academic program culminates in the regents examination, a comprehensive examination, in this case, taken after a year of chemistry). Along with the chemistry teachers were three teachers of eighth grade general science and three teachers of ninth grade general science. In pretesting, the latter teachers, (general science), were selected from all the general science teachers at that school for greatest divergence in I/D ratio. Students were randomly placed in the general science and chemistry classes by the guidance departments of the respective school. The second general area was the recording of the achievement scores (standardized final examination in the general science classes and the regents examination in the chemistry classes) and the subsequent determination of the degree of correlation between the I/D ratio of the teacher and the achievement scores of his students. The third general area was the retesting of the students after approximately four months, with the same examination, to obtain a "retention score". This score was then compared to the original score, called an "achievement score", and then converted to a percent to be known as the "percent retention". It was then determined to what degree the I/D ratio of the teacher was related to the "percent retention" of his students.

The I/D ratio for the teachers was obtained by observing and coding, according to the 10-point category system of Ned A. Flanders, at least 12 class sessions for each teacher during the school year. The sessions were consistent for each teacher, i.e. several at the beginning of the year, several at mid-year, and the rest at the end of the year. The teachers were approximately equivalent in background and training.

The students took their achievement test in June and were retested at the beginning of October of the same year, so that there was no instruction in chemistry in between, and the amount in general science was insignificant. Class means for the achievement and retention tests were subjected to an analysis of variance to test for significance of differences.

Session Ic - Factors Influencing Student Achievement in Science

Chairman: Paul Westmeyer, Florida State University, Tallahassee, Florida

1. "Factors Affecting College Students' Achievement in Science," George G. Mallinson, Western Michigan University, Kalamazoo, Michigan.

2. "The Distinguishing Characteristics of High Schools With High and Low Enrollments in Physics," Thomas E. Van Koevering, The University of Wisconsin-Green Bay, Manitowoc, Wisconsin.

3. "Relationships of Teacher-Assigned Grades in High School Chemistry to Taxonomy-Type Objective Test Scores," Alexander Even, The Ontario Institute for Studies in Education, Toronto, Ontario.

4. "Conceptual and Factual Educational Set of Teacher and Learner on Performance in the BSCS Curriculum," Donald Lee Troyer, Western Illinois University, Macomb, Illinois.

5. "Development of a Cognitive Preference Examination for Use in Secondary and Higher Education," Ronald K. Atwood, University of Kentucky, Lexington, Kentucky.

FACTORS AFFECTING COLLEGE STUDENTS' ACHIEVEMENT IN SCIENCE

George G. Mallinson
School of Graduate Studies
Western Michigan University
Kalamazoo, Michigan

The purpose of this study was to investigate the collegiate experiences, with particular reference to achievement in courses in science, of 1,191 students who graduated from high school in June, 1963, in 12 Midwestern high schools. The students were members of a group of over 6,000 participants in a science motivation study conducted from 1957-63. The study reported herein was designed to determine the extent to which factors such as interest, intelligence, high-school achievement, and family background might be related to the election of, and success in, college science courses.

Four primary sources of data were used for this study: (1) a reanalysis of scores on standardized tests administered to the participants when they were in secondary school; (2) college transcripts; (3) Kuder Preference Records completed by the participants during their freshman and junior years of college; and (4) questionnaires to which they responded during their sophomore and senior years. The data thus collected were used also to compare the college students with a group of their non-college-bound peers.

The findings indicate that, as was expected, the college students differed from their non-college-bound peers in that they had higher I.Q.'s; came from homes of higher socio-economic level; and had parents with higher aspirations for the education of their children.

Of the total group entering college, about 85% enrolled immediately following high-school graduation, the vast majority in large state-supported institutions. Of the 849 who had received a bachelor's degree by February 15, 1968, 71% graduated from state-supported institutions.

The two most significant factors related to overall achievement in college were the student's I.Q. and his belief that his parents thought education was important. With respect to the election of, and achievement in, science courses an influential factor, in addition to the two above, was the number of science courses taken in high school. Interest in science, as indicated by the Kuder Preference Record during college seemed to have little influence, since many of those who majored in science did not evidence interest on the test.

Success in college was not found to be related to either the size of the high school from which a student graduated or the size of the college he attended. Students with the same I.Q. received substantially the same grades in one type of institution of higher education as they did in another.

THE DISTINGUISHING CHARACTERISTICS OF HIGH SCHOOLS WITH HIGH AND LOW ENROLLMENTS IN PHYSICS

Thomas E. Van Koevering
The University of Wisconsin-Green Bay
Manitowoc Campus
Manitowoc, Wisconsin

The purpose of this study was to determine if measurable differences exist between high schools with high and low enrollments in physics. Questionnaires were sent to one-half of the high schools in Michigan and from rank-order lists of the percentages of seniors enrolled in physics for Class A, B, and C high schools. Fifty-two schools were selected as a sample population. One-half of the schools were considered to have high and the other half low percentage enrollments in physics. A visit was made to each of the high schools and questionnaires were administered to 55 physics teachers, 52 guidance counselors, 1429 physics students, and 2338 chemistry students.

Data were obtained from four primary areas: (1) the Sixteen Personality Factor Questionnaire and a background and opinion questionnaire completed by the physics teachers; (2) the physics students' evaluations of their physics teachers and the physics classroom environments as well as their reasons for taking physics, their grades in all their courses, and their achievements on the Dunning-Abeles Physics Test; (3) the chemistry students' reasons for wanting or not wanting to take physics; and (4) the opinions of the guidance counselors.

The findings indicate that the most significant difference between the physics teachers in the high and low enrollment groups was that the physics teachers in the high enrollment groups were more affected by feelings. These teachers were also more unpretentious, more experimenting, and somewhat more enthusiastic about the subject they were teaching.

More physics teachers and guidance counselors from the high enrollment groups believe that geometry or less is sufficient as a mathematics prerequisite for physics than do their counter parts in the low enrollment groups.

A higher percentage of the students from the high schools with high physics enrollments expressed vocational plans in non-science areas. A higher percentage of this group indicated they were taking physics because they thought they would like the teacher or because their friends were taking the course, whereas larger percentages of the students from the low enrollment groups selected physics because it was required or they enjoyed the challenge.

Physics students in both enrollment categories received lower grades in physics than in their other academic courses. The physics students in the high physics enrollment groups are on the average poorer students in all areas than students from the low enrollment groups. The Dunning-Abeles Physics Test scores, from a small segment of the sample schools included in a comparison, indicate that students do equally well from high schools with either high or low enrollment percentages in physics.

The percentage of high school graduates going on to college has a positive influence on physics enrollments.

PSSC materials do not appear to be exerting either a positive or negative effect on enrollments as reflected by the number of teachers in each enrollment group using them.

RELATIONSHIPS OF TEACHER-ASSIGNED GRADES IN HIGH SCHOOL CHEMISTRY TO TAXONOMY-TYPE OBJECTIVE TEST SCORES

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The Ontario Institute for Studies in Education
Toronto, Ontario, Canada

The study was designed (a) to investigate the relationship between Chemistry grades and the scores obtained on a test built on Categories 1.00 to 4.00 of Bloom's Taxonomy, and (b) to compare the contributions of various predictor variables to the explainable variance of the grades and total test scores.

The Ontario Test of Achievement in Chemistry (OTAC), a 60-item end-of-course test, developed over a 3-year period by the author, was administered in mid-May of 1964 to 2,339 grade 12 general course (college preparatory) students in 30 Ontario high schools selected at random. The Inventory of Choices, an attitude-measuring instrument devised by Edwards and Wilson, was also administered. Other information collected included final grades in Chemistry, scholastic aptitude test scores, sex, occupation of father and mother, language spoken in the home, educational plans, and type of school.

The University of Michigan Automatic Interaction Detector (AID) computer program was used to identify variables contributing to the explainable variance of the two sets of achievement scores, and to isolate groups of students in which different combinations of these predictors functioned most effectively.

Teacher-assigned grades were found to be not highly correlated with OTAC total scores and subtest scores; the correlation between Analysis (Taxonomy Category 4.00) and grades was much lower than other correlations. With the exception of Category 4.00 scores, OTAC scores were more highly correlated with scholastic aptitude than were grades. Correlations of scores and grades were generally higher with mathematical aptitude than with verbal aptitude except in Category 4.00 where the correlation with verbal aptitude was higher than with mathematical aptitude.

The AID Analysis shows that mathematical aptitude is the best dichotomizing (explanatory) variable for both OTAC total scores and Chemistry grades; verbal aptitude is the next best splitter, for both OTAC scores and grades, for those students obtaining an above-average score in mathematical aptitude.

For other students, the Immediate Educational Plans variable functions more effectively than verbal aptitude in explaining chemistry grades; verbal aptitude, however, is a better explanatory variable than immediate educational plans where OTAC total score is the dependent variable.

The Theoretic-Immediate variable of Edwards and Wilson operates most effectively in a different verbal aptitude range in explaining final chemistry marks than it does in explaining OTAC scores.

The variable Repeating, which did not function effectively in explaining OTAC total scores, is a good predictor of final chemistry grades for students of moderate to low mathematical ability who do not plan to enter university.

It was seen that those independent variables which are useful as predictors for both OTAC scores and teacher-assigned grades operate to explain the variance of the dependent variable in quite different ways. The ratios of mathematical aptitude to verbal aptitude in terms of variance explained are especially striking.

The findings also suggest that the same accomplishments are not being measured by grades and OTAC scores, and that comparatively little emphasis has been placed, either in teaching or examining, on the achievement of abilities which are subsumed under the cognitive objective Analysis.

CONCEPTUAL AND FACTUAL EDUCATIONAL SET OF TEACHER AND LEARNER ON PERFORMANCE IN THE BSCS CURRICULUM

Donald Lee Troyer
Western Illinois University
Macomb, Illinois*

The purpose of this investigation was to determine if achievement in the classroom is influenced by the educational set possessed by the teacher and student. In addition, this study was to examine the impact teacher flexibility has on achievement of conceptual and factual information.

The population was selected from schools that were teaching Yellow Version BSCS Biology in a mid-western area. The final participants included 30 teachers and 1773 students from 16 schools.

The data were collected in the following manner: (a) all teachers took the Educational Set Scale and the Philosophic-Mindedness Scale, (b) all students were given the Educational Set Scale, and (c) the teachers administered the first quarterly BSCS Yellow Examination (1 YR, 1963) to their students after completing those chapters that comprise the material from which the examination was drawn. The Educational Set Scale scores were used to categorize the teachers and students as possessing a conceptual or factual educational set. The Philosophic-Mindedness Scale scores were used to categorize the teachers as being high or low in flexibility.

The BSCS Yellow Examination questions were classified into factual and conceptual questions. Thus, a factual examination, a conceptual examination, and a factual-conceptual examination were developed from the BSCS Yellow Examination to be used as the dependent variables. The educational set of the teachers and students and the philosophic-mindedness of the teachers served as independent variables. The data were analyzed by utilizing correlation with transgeneration and analysis of variance.

The following conclusions were reached:

1. Conceptual students achieve significantly higher than factual students on the three posttest measures.

2. Student achievement was significantly greater under a conceptual teacher than under a factual teacher on the three posttest measures.

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* The research and writing of this report was completed while the author was at the Science Education Center, Indiana University, Bloomington, Indiana.

3. Student achievement was significantly greater under a teacher demonstrating a low degree of flexibility on the three posttest measures.

4. There was a positive and significant correlation (.39) between the teachers' scores on the Educational Set Scale and the teachers' scores on the Philosophic-Mindedness Scale.

Implications and recommendations include the following:

1. Those students possessing a certain type of educational set are favored with regard to achievement in the classrooms.

2. Student educational set can serve as a predictor of classroom achievement.

3. Further research should be undertaken to determine if the school can aid a student to modify his educational set without a resultant damaging effect on the child, and in this manner enhance his learning potential.

4. The educational set does influence the instructional strategies employed by the teacher as demonstrated by the differential in student achievement under teachers with differing educational sets.

5. An investigation should be undertaken to determine how teachers can be aided to modify their educational set and thus their classroom behavior so that student achievement may be enhanced.

6. The concept of teacher flexibility in the classroom should be re-examined.

7. There exists a need to determine the characteristics exhibited in the classroom by the conceptual teacher who is low in flexibility which accounts for the higher level of student achievement under this type of instructor.

8. When all other factors are equal, a conceptual teacher low in flexibility should be favored for placement in the classroom over a teacher possessing any other combination of educational set and flexibility.

DEVELOPMENT OF A COGNITIVE PREFERENCE EXAMINATION FOR USE IN SECONDARY AND HIGHER EDUCATION

Ronald K. Atwood
University of Kentucky
Lexington, Kentucky

The purpose of the work described in this paper was to develop a cognitive preference examination for use in secondary and higher education. In order to maximize the utilization of the cognitive preference concept, it was felt that an examination was needed in which the content of the items would be familiar to a broad spectrum of students.

Using general science and social science as the content vehicle, a pool of three-preference (memory, application and questioning) items was written and submitted to a panel of judges. The panel, including a specialist in science education, social science education and educational measurement, critiqued each item in terms of content accuracy and the presence and quality of the preference options. Some of the items not receiving unanimous approval were revised; others were deleted.

After three judging and revising cycles, the thirty-five items receiving unanimous approval were printed and administered to three classes enrolled in the summer, 1969, session of the University of Kentucky. The results were analyzed and eight poorly functioning items were eliminated; three of these items were replaced with distractor items.

During the current semester the thirty-item test is being administered to a sample of university and secondary school students enrolled in a science or science methods course. The results will be used in another item analysis and for obtaining reliability information. Some student interviews are being conducted in which a student is asked to introspect regarding his choices on some of the items; the student is given this task immediately after taking the test, but before he is told what the test attempts to do.

When the results of the fall field tests are studied, some judgment will be made about whether further revisions and/or trials are needed.

By drawing content from general science and social science, it is felt that an instrument can be developed which will be useful in studies involving both science and non-science majors. It may be especially useful in longitudinal studies where familiarity of content in the preference item would need to be controlled.

GENERAL SESSION A

Presiding: Paul DeHart Hurd, Stanford University, Palo Alto, California

Speaker: David P. Ausubel, The City University of New York, New York

"The Use of Ideational Organizers in Science Teaching"

Since the potential meaningfulness of a learning task depends in large measure on its relatability to a particular learner's structure of knowledge, cognitive structure--both its substantive content and its major organizational properties--is a principal factor influencing meaningful learning and retention in a classroom setting. The use of advance organizers represents one way of pedagogically manipulating cognitive structure so as to facilitate school learning. Its rationale is based on (a) the importance of having relevant and otherwise appropriate established ideas already available in cognitive structure to make logically meaningful new ideas potentially meaningful and to give them stable anchorage; (b) the advantage of using the more general and inclusive ideas of a discipline as the anchoring ideas or subsumers (namely, the aptness and specificity of their relevance, their greater inherent stability, their greater explanatory power, and their interpretive capacity); and (c) the fact that they themselves attempt both to identify already existing relevant content in cognitive structure (and to be explicitly related to it) and to indicate explicitly both the relevance of the latter content and their own relevance for the new learning material. The application of advance organizers to science teaching is explored in detail, and three general content issues in secondary school biology teaching are considered--desirable levels of sophistication, the naturalistic versus the analytical-experimental-quantitative approach, and the "basic" versus the "applied" approach.

Concurrent Sessions II

Session IIa - Attitude Assessment in Science

Chairwoman: Mary Budd Rowe, Teachers College, Columbia University, New York

1. "Attitude Assessment and Development in High School Sophomore Biology Students," Lynn W. Glass, University of Iowa, Iowa City, Iowa.
2. "The Development, Field Test and Validation of an Inventory of Scientific Attitudes," Richard W. Moore, Miami University, Oxford, Ohio, and Frank X. Sutman, Temple University, Philadelphia, Pennsylvania.
3. "The Effects of an Increased Time Allotment on Student Attitudes and Achievement in Science," Gene M. Deady, Chico State College, Chico, California.
4. "The Formation of Alternate Theories by High School Biology Students to Those Held by Student Teachers," R. Keith Hanson, Urbana Junior High School, Urbana, Illinois.

ATTITUDE ASSESSMENT AND DEVELOPMENT IN HIGH SCHOOL SOPHOMORE BIOLOGY STUDENTS

Lynn W. Glass
University of Iowa
Iowa City, Iowa

Much research has been undertaken in the past decade in the area of cognitive growth and development. However, comparatively little has been undertaken in the affective domain.

It is the purpose of this paper to report progress on the development of an instrument to determine the teacher's and students' educational objectives in the affective domain for a sophomore biology course and also to illustrate a correlation technique whereby a profile of the teacher's educational objectives can be correlated with each of his students' educational objectives.

Eight teachers utilizing the BSCS Biological Science:Molecules to Man course and their 640 students were selected to be involved in a yearlong study. A 65 item attitude assessment scale emphasizing the same subject matter as Biological Science:Molecules to Man and structured according to Krathwohl, Bloom and Masia was developed and administered to each teacher and student during the first week of the school year.

Based on this attitude assessment scale a profile of educational objectives in the affective domain was developed for each teacher and student. The profile of each teacher was then matched on a +1 to -1 basis with the profile of each of his students. An analysis of the pretest results will be presented.

In May the same attitude assessment scale will be administered to ascertain any change in educational objectives in the affective domain.

The educational importance of this research may be in the identification of educational objectives in the affective domain that are transferred from teacher to student during a given sophomore biology course.

THE DEVELOPMENT, FIELD TEST AND VALIDATION OF AN INVENTORY OF SCIENTIFIC ATTITUDES

Richard W. Moore
Miami University
Oxford, Ohio

Frank X. Sutman
Temple University
Philadelphia, Pennsylvania

This study involves the development, field test and validation of the Scientific Attitude Inventory for use at the high school level.

The Inventory consists of twelve attitude scales representing the following types of scientific attitudes: (1) positive intellectual, (2) negative intellectual, (3) positive emotional, and (4) negative emotional. Each scale consists of a position statement or statement of the attitude being assessed, and five Likert-type attitude statements to assess the extent to which the respondent accepts the related position.

The attitude statements finally used were selected from a pool of items on the basis of: (1) judgments of a panel of judges about whether one's acceptance of the statement could be taken as evidence that he assumes the related position, and (2) responses of a group of high school students to the attitude statements. Content validity is claimed for the Inventory on the basis of the judgments of the panel of judges and the inclusion of items from each subdivision of the universe of content--"scientific attitudes."

The construct validity of the Scientific Attitude Inventory was demonstrated in the field test involving three intact high school biology classes. The Inventory was given to each group as a pre- and posttest. A control group received six lessons prepared by their regular teacher. This group had a significant decrease in means from pretest to posttest at the .05 level. A second group was given six lessons designed to develop the attitudes assessed by the positive scales of the Inventory. There is no significant difference between the pretest and posttest means of this group; however, the group had a significant increase on the positive scales of the Inventory and no change on the negative scales from pretest to posttest The third group received six lessons designed to develop the attitudes assessed by the positive scales of the Inventory and to eliminate the attitudes assessed by the negative scales of the Inventory. For this group, there was a significant increase in means from pretest to posttest at the .001 level. These changes are compatible with theoretical prediction of the direction of change, therefore, construct validity is claimed for the Scientific Attitude Inventory.

The posttest mean of each group was compared with the post-test mean of every other group in an analysis of covariance in which pretest score, I. Q., and science grade-point average were statistically controlled. It was found that the treatments given to the experimental groups were more effective in producing a positive change in the assessed attitudes than the treatment given the control group. There was no difference between the treatments given the experimental groups.

Further analyses of the data revealed that:

1. the Scientific Attitude Inventory test-retest reliability estimate is 0.934.

2. the method of item selection used in this study meets the minimum requirements of a recognized method of item selection for a summated-rating scale.

3. sex is not a factor affecting students' scores on the Inventory.

4. the Inventory is as appropriate for use with students in biology as for students in physical science classes.

THE EFFECTS OF AN INCREASED TIME ALLOTMENT ON STUDENT ATTITUDES AND ACHIEVEMENT IN SCIENCE

Gene M. Deady
Chico State College
Chico, California

The four problems examined in this study attempted: to investigate whether an increased time allotment increases student achievement in science; to determine whether the teacher's preference for a particular time allotment for science instruction effects student achievement in science; to ascertain whether an increased time allotment to science instruction effects student attitudes toward science; to determine whether the teacher's preference for a particular time allotment for science instruction effects student attitudes toward science.

This was an experimental and control group study conducted with 16 classes of fourth-grade students. A total of 324 children participated in the study.

Both experimental and control group classes were conducted in each school during the entire school year. Children were randomly assigned to classes, and teachers within schools drew lots to determine experimental and control group teaching assignments. Information concerning teacher background and science time allotment preference was obtained by using a questionnaire constructed by the author.

Four teacher preference and assignment groups were obtained from this information: Preferred Minimum--Assigned Minimum; Preferred Minimum--Assigned Increased; Preferred Increased--Assigned Minimum; Preferred Increased--Assigned Increased.

To establish pre-experimental groupings, measures of I. Q. and reading were obtained from the cumulative files for each student.

Pre-experimental measures of general science knowledge were obtained by using the Cooperative Sequential Tests of Educational Progress, Science, Form 4A (STEP).

Pre-experimental measures of fourth-grade science knowledge were obtained by using the author's Science Achievement Test (SAT). The author's test consisted of 50 multiple choice questions based on the fourth-grade science curriculum as presented in Concepts in Science, 4, the California State science textbook. The reliability and validity of the SAT were established in a pilot study.

Pre-experimental measures of attitudes toward science were obtained through individual interviews using Lowery's Projective Tests of Attitudes (PTOA).

Post-experimental measures were obtained by repeating the same tests in the same form.

The statistical test used in the study were the F test and the H test. The F test was used to measure mean differences between groups within schools. The H test was used to measure differences between mean rank scores of the four teacher preference and assignment groups.

Data were organized and processed on an IBM 6400 computer using the BMD 08V and ARIEL programs. The decision rule established for the analysis was to reject the null hypothesis whenever the probability of committing a Type I error was equal or less than .01.

Analysis of the mean rank scores of the four teacher preference and assignment groups on all of the pretest criterion measures revealed no significant differences.

Similarities in knowledge of general science, fourth-grade science, and attitudes toward science between experimental and control groups were established on the pretests. Differences between schools were observed on all criterion measures, but only one significant difference between groups within schools was detected. This was attributed to random effects. Differences between sexes, I.Q. groups, and reading groups within experimental and control groups within schools were attributed to random effects.

The eight experimental group teachers reported a mean of 35 minutes of science instruction per day, and the eight control group teachers reported a mean of 20 minutes of science instruction per day. This information was reported on Time Logs supplied by the investigator.

At the conclusion of the research period, no significant differences could be attributed to the treatment variable of the teacher preference variable when examined across experimental groups, sexes, I.Q.'s, or reading groups. Infrequent interactions were attributed to random effects. Differences between schools were again observed at the completion of the experimental research.

THE FORMATION OF ALTERNATE THEORIES BY HIGH SCHOOL BIOLOGY STUDENTS TO THOSE HELD BY STUDENT TEACHERS

R. Keith Hanson
Urbana Junior High School
Urbana, Illinois

This research describes the interaction of student teachers and students attempting inquiry. This report also considers the relationship of the student teachers to their own subject matter and contrasts this relationship with the student's relationship to his own knowledge. The study was descriptive, and data were collected from video-recordings of microteaching sessions in the context of a high school biology class. Student teachers worked in pairs, two student teachers with two to four high school freshmen. While one student teacher taught, the other kept a record of episodes judged significant in some way by the observer. Twelve student teachers enrolled in a methods course at the University of Illinois were studied during the spring semester of the 1968-69 school year.

The research focused on the student's interpretation of data that the student teacher presented to the class, and the student teacher's reaction to the student's interpretation of the data the teacher presented. Analysis of the tapes shows that there are times when students posit explanations the student teachers find unsatisfactory, but which fit the data that the student teacher has presented to the students to examine. The explanations that the students advance are genuine alternatives to the ones that the student teachers hold to be the proper explanation for the data that the student teacher has presented to the students. These alternate explanations that students advance are called alternate theories, following T. S. Kuhn's use in describing how science advances by revolutions, in which alternate interpretations of nature play a necessary role.

Alternate theories arise in science teaching by inquiry much as they do in the history of science. An understanding of alternate theories is a means of clarifying key difficulties beginning science teachers have. Alternate theories represent a range or a continuum. The problem for the student teacher is, what to do with them when they arise. This research shows that one problem the student teacher has with alternate theories is related to the student teacher's own theoretical background. The existence of an authenticated theory in the teacher's mind makes it difficult for him to see or understand that the student is advancing a genuine alternative to the view that he holds. This study does not answer the question what should be the student teacher's response to alternate theories that students advance. Rather, it demonstrates the existence of alternate theories and that they are reasonable alternate explanations of the data that students are expected to interpret.

These alternate explanations are thought to be unreasonable when, as in the case of the student teacher, one knows the accepted explanation. This is the source of the problem.

Implications of the study are that guiding inquiry and correcting the logic of the students participating in an inquiry hides from the students the manner in which we acquire knowledge. Rather than helping students become learners who understand how knowledge is acquired, student teachers are seen as preventing students from understanding how knowledge is acquired. The manner in which the student teachers transmit knowledge can be attributed to the inadequate philosophic and historic base the student teachers receive in their subject matter coursework.

Session IIb - Children's Learning in Science

Chairman: N. E. Bingham, University of Florida, Gainesville, Florida

1. "A Study of Outcomes of Mutually Aided Learning," Ronald D. Anderson, University of Colorado, Boulder, Colorado, Albert R. Thompson, Cherry Creek Schools, Englewood, Colorado, and Arthur White, Ohio State University, Columbus, Ohio.

2. "Transfer of Learning Experiences in Science of Elementary School Children," Leon Winslow and David Sorenson, Spring Arbor College, Spring Arbor, Michigan.

3. "A Study of the Ability of Primary School Children to Generalize Behavioral Competencies Specified for Science - A Process Approach to Other Content Settings," Heather L. Carter, University of Texas, Austin, Texas.

4. "The Influences of Curriculum Differences and Selected Teaching Strategies on the Cognitive Preferences of Elementary School Science Students," Gary Schmedemann, Lawrence, Kansas.

A STUDY OF OUTCOMES OF MUTUALLY AIDED LEARNING

Ronald D. Anderson
University of Colorado
Boulder, Colorado

Albert R. Thompson
Cherry Creek Schools

Arthur White
The Ohio State University
Columbus, Ohio

The purpose of the study is an assessment of mutually aided learning, an instructional process in which teams of trained high school students (called learning assistants) serve as instructors of elementary school children. Each learning assistant in a team worked with a group of 4 or 5 elementary children during the science (ESS) portion of the school program. The elementary school teacher was present and in charge of her class but the instruction was conducted by the learning assistants. This study was limited to an assessment of the cognitive outcomes among the elementary students.

Eight classes in two schools (2 experimental and 2 control classes in each school) participated in the study. In one school the students were randomly assigned to the science classes and in the second school assignment was done by a procedure intended to produce equivalent classes although it was not random assignment. Examination of I.Q. scores showed that the classes in this school were at least as equivalent as those in the randomly assigned classes. The statistical analysis included blocking on I.Q. which provides further assurance that any outcome differences in this school are not due to lack of equivalent groups. A post-test only design was employed. The dependent variables were scores on (1) a concepts application test (requires application of knowledge in concrete situations), (2) a standardized science achievement test, (3) a creative thinking test composed of three scales, and (4) a critical thinking test composed of three scales.

A separate analysis was conducted for each school within a 4 x 2 x 2 nested factorial design in which the independent variables were teacher (4 levels), learning assistant (2 levels), and I.Q. (2 levels). Learning assistant was nested in teacher. An analysis for the combined data from the two schools was conducted within an 8 x 2 x 2 x 2 nested factorial design in which the independent variables were teacher (8 levels) and school (2 levels), learning assistant (2 levels), and I.Q. (2 levels). Teacher was nested in learning assistant and learning assistant was nested in school.

The results of the analysis show that the three factors of (1) learning assistant, (2) teacher, and (3) school were influential and there were some interactions among them. This is consistent with other research findings which show that there are many factors which cause variations in student outcomes and it also provides further evidence

that the primary determiners of cognitive learning lie somewhere in the complex pattern of interactions between students and the many individuals who constitute "their world." Whatever these major determiners are, however, their influence, either positive or negative is not mainly established by the absence of presence of learning assistants in the classroom.

TRANSFER OF LEARNING EXPERIENCES IN SCIENCE OF ELEMENTARY SCHOOL CHILDREN

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The purpose of this study was to determine some basic processes in positive transfer of simple concepts in science of elementary school children.

The two investigators worked first with individual students to determine whether the four or five similar problems were arranged in the series according to increasing difficulty. They then worked with individuals to determine the degree of positive transfer (or negative transfer) which occurred. Entire classes were then used to try to find out basic processes in operation in the classroom setting in order to effect positive transfer. Several series have been tested, for instance: the concept that "air pressure is greater where the air is moving more slowly than where it is moving rapidly," and "the center of gravity is the point about which an object will be balanced."

At this stage in our research we have determined a good order of increasing difficulty in the series. We are gathering data on both the degree of positive transfer of individuals and the basic processes at work in the classroom to effect positive transfer. An exciting and imaginative study of science will bring about some increase in the ability to use scientific concepts and fact in a functional and meaningful way. By giving teachers more options for them to use, as these experiences may do, we increase the possibility of teachers helping students to become "inner teachers" to be effective in Century 21.

A STUDY OF THE ABILITY OF FIRST THROUGH FOURTH GRADERS TO GENERALIZE BEHAVIOR SPECIFIED FOR SCIENCE -- A PROCESS APPROACH TO OTHER CONTENT SETTINGS

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The purpose of this study was to test the following hypothesis: "Students who attain a specific level of behavioral competence, as determined by performance tasks for science, demonstrate acquisition of behaviors at the same level or higher when determined by performance tasks in social studies." Similar hypotheses were constructed for fine arts and language arts.

The Science Process Instrument was used to assess the student's performance in science. The measure evaluates students' competence with respect to behavior described in the elementary science program, Science-A Process Approach. Items were constructed in the field of social studies, fine arts and language arts using the same format and construction restrictions as were imposed in the development of the science tasks. One item was developed for each of the behaviors described in the science sequence. The highest level of acceptable performance in science was then compared with the highest level of acceptable performance in each of the other content areas. The data collected were analyzed and tested for significance to determine whether support for the stated hypotheses had been observed.

The sample for the investigation was randomly chosen from the population of first through fourth graders in Oshkosh, Wisconsin which had used the AAAS elementary science materials.

The findings of this investigation did support the hypotheses for all content areas when analyzed for the entire group of first through fourth graders. However, when the data were analyzed by grade and by sex the frequency of higher or equivalent levels was no different from that which would have occurred by chance for the third and fourth graders and for the boys in language arts and for the third graders in fine arts.

The independent development of curriculum at the elementary school level for separate content areas does not seem justifiable. Competencies common to several content areas need not be introduced for all students in each of the settings. This suggests that a useful contribution to curriculum development would be to identify a collection of common objectives for several content settings and then for instructional materials to be developed for the specified behaviors using a variety of content settings. This would not preclude the existence of behaviors which are specific to a content setting and which must necessarily be taught within that discipline.

THE INFLUENCES OF CURRICULUM DIFFERENCES AND SELECTED TEACHING STRATEGIES ON THE COGNITIVE PREFERENCES OF ELEMENTARY SCHOOL SCIENCE STUDENTS

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During the past eight years, development of new science curriculum programs has been extended to include the elementary school curriculum. Common to the efforts of the national curriculum projects is the broadening of the goals of science teaching to include pupil discovery of principles underlying natural phenomena and the acquisition of a scientific attitude. This study was designed to discover the influences of the Elementary Science Study program and of certain teaching strategies on the facet of scientific attitude termed "cognitive preference."

Two experimental instruments, the Cognitive Preference Measure (CPM), and the Teaching Strategy Inventory for Teachers (TSI) were constructed especially for use in this study. Students completing the CPM indicated their relative preferences for three types of information as approaches to solving problems in science: (1) facts, (2) identifying a fundamental principle, and (3) challenging or questioning experimental procedures. The TSI is a forced-choice inventory through which the teachers revealed their use of certain teaching procedures. The Sequential Tests of Educational Progress, Science Form 4A (STEP) was used as a measure of student aptitude.

The CPM and STEP tests were administered to a sample of 476 students in the fall of 1968. The CPM was administered to the same students again the following spring; at this time, their teachers completed the TSI. An item analysis was made of the CPM. The validity of the items on the TSI was determined from a scalogram analysis. Ten "null" hypotheses were tested using the General Linear Hypothesis, a multiple regression technique.

The results of the analysis may be summarized as follows:

1. There is no significant relationship between the cognitive preferences of students and the teaching strategies selected by their teachers.

2. There are no significant differences between the cognitive preferences of the students in the three groups of the study.

3. There is no significant relationship between aptitude and the cognitive preferences of the students.

Knowledge of pretest scores on the Cognitive Preference Measure was found to contribute significantly to the prediction of post-test scores.

In order to determine whether prevailing teaching practices were in agreement with current viewpoints of good teaching procedures, response patterns of teachers on the scalable items of the TSI were compared with the responses of nine graduate students in science education. The teaching strategies used by the experimental group teachers were in closer agreement with the theoretical viewpoint than were the strategies of the teachers in the control groups.

From the above results, three conclusions are possible: (1) on the bases of the variables used for grouping, no real differences existed; (2) there were differences among the cognitive preferences of the groups of students, but these differences were not detected by the instrument developed for this study, or (3) there were differences in criterion scores between groups, but use of pretest scores as an independent variable masked the post-test contrasts.

If the first possibility is in fact the true one, then questions should be raised concerning the effectiveness with which the objectives of the Elementary Science Study are being realized. Perhaps more conventional methods and materials are equally effective in assisting students in the identification of fundamental principles and challenging or questioning experimental procedures.

The finding that pretest scores on the CPM were good predictors of post-test scores suggests that cognitive preferences are a rather stable part of an individual's cognitive structure, and that perhaps seven months in normal classroom settings was not long enough to bring about changes which could be detected by group testing.

Although there were no significant differences between the response patterns of practicing teachers on the scalable items of the TSI when compared with the response patterns of graduate students in science education, the results suggested that the viewpoints of the graduate students was approximated more closely by the experimental group than by the control groups.

Concurrent Sessions III

Session IIIa - Piagét Based Learning Studies in Science

Chairman: Robert G. Bridgham, Stanford University, Palo Alto, California

1. "The Effects of a Piagét Based Program Designed to Induce in Elementary and Jr. High School Students Basic Correlational Analysis Using Biological Phenomena," Albert P. Nous, University of Pittsburgh, Pittsburgh, Pennsylvania, and Ronald J. Raven, The State University of New York at Buffalo, Buffalo, New York.
2. "The Effect of Instruction on the Acquisition of Conservation of Volume as Defined by Piagét," Ann C. Howe, Southwest Educational Development Laboratory, Austin, Texas, and David P. Butts, The University of Texas, Austin, Texas.
3. "Organizer Influence on Childrens' Answers to Questions of Physical Causality," James Harding and Howard L. Jones, The University of Houston, Houston, Texas.
4. "The Effect of an Equilibrated Methodology on the Acquisition of the Concept--Conservation of Quantity," Hansom Prentice Baptiste, Jr., Indiana University at South Bend, South Bend, Indiana.
5. "Piagetian Studies: Effect of Sub-Cultural Pressure in Quantification Upon Task Performance," Robert R. Buell, The University of Toledo, Toledo, Ohio.

THE EFFECTS OF A PIAGET BASED PROGRAM DESIGNED TO INDUCE IN ELEMENTARY AND JR. HIGH SCHOOL STUDENTS BASIC CORRELATIONAL ANALYSIS USING BIOLOGICAL PHENOMENA

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It is proposed that the teaching of processes is the highest form of content in any curriculum. The problem is to determine what processes are important. In this paper the authors propose that the discipline itself provides the basis for selection of the relevant processes. One example is the correlational science of biology. As such the ability to correlate is not only a function of development but is also a function of training. This process is neither explicated nor taught although the biology curriculum and textbook publishers test and present data that can only be analyzed using correlational thinking.

The purpose of this study is to examine the various abilities subsumed under the process of correlational thinking. Each of these major abilities is translated into behavioral activities and procedures in six booklets. Each booklet therefore corresponds to a specific major ability and is placed, with respect to the other booklet, in a sequence that is considered by the authors to be highly structured. The specific abilities are Logical Class Formation, Logical Class Manipulation, Logical Class Negation, and Correlation Formation. At the end of this structured sequence the individual will be able to perform correlational analysis using combinations of class dichotomized variables. The endpoint of correlational analysis refers to the statement of a relationship or rule by the individual when presented with event frequencies of variable combinations in either a random order or a two by two matrix.

This study was undertaken when, in teaching ecological concepts from the systems viewpoint, it was realized that correlational analysis was an ability basic to and necessary for transcending the gap between pure classification and systems analysis.

A three factor fixed effects, sex (2) X grade level (3) X IQ Level (3), multivariate analysis of covariance model was applied using a total N = 365 students. Students were selected from parochial schools

in the Catholic Diocese of Buffalo, New York. Fifth, seventh, and ninth graders composed the grade levels which in themselves constituted a developmental level. The three IQ levels I, II, III contained students with IQ scores from 70 to 99, 100 to 109, and 110 to 135, respectively.

Age, probability pretest scores, and six pretest sequence scores served as covariates. The dependent variables consisted of total scores on each program booklet and six post-test sequence scores.

An F value of 5.5178 ($p<.0001$, with 96,2287 df.) was obtained for the test of the hypothesis of no association between dependent and independent variables, thus indicating the significant effect of the program itself.

Above and beyond the first covariate, age, all other covariates proved to be significant with $p<.01$.

The multivariate F ratios for sex ($F = 4.5407$, $p<.0001$, with 12,338 df.), IQ level ($F = 3.1102$, $p<.0001$, with 24,676 df.) grade level ($F = 4.2067$, $p<.0001$, with 24,676 df.), and sex X grade interaction ($F = 3.1116$, $p<.0001$, with 24,676 df.) proved significant.

The results indicate that the ability to correlate as studied in this program and subsequently developed, when incorporated into the teaching of certain biological concepts will provide an effective basis for promoting concept understanding from the systems viewp-int.

THE EFFECT OF INSTRUCTION ON THE ACQUISITION OF CONSERVATION OF VOLUME AS DEFINED BY PIAGET

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Gagne's theory of cumulative learning proposes that a task can be learned if the competencies which are subordinate to it can be identified, described in behavioral terms and taught in sequence. Piaget's cognitive-developmental theory stresses the role of processes which are internal to the learner and are not dependent on outside events. The work reported here was undertaken to test the hypothesis that science instruction based on task analysis will lead to the acquisition of the ability to perform certain Piaget volume tasks which have been characterized as requiring formal operations for their solution.

Two volume tasks were identified and analyzed to produce learning hierarchies which incorporated ideas of Gagné. A Test of Formal Operations, a Learning Hierarchies Achievement Test, and an instructional program based on the learning hierarchies were developed.

The two tests were given to fourth- and sixth-grade students in a school which had used Science-A Process Approach and to fourth- and sixth-grade students in another school which had not used Science-A Process Approach. After pretesting, students at each grade level at each school were divided by random assignment into experimental and control groups. The experimental groups received instruction based on the learning hierarchies; the control groups received instruction not related to the hierarchies. All children were posttested with the instruments used in the pretest.

It was found that ability to perform the volume tasks at fourth-grade level may be related to experience in Science-A Process Approach. A similar relationship for sixth-grade students was not found. Experience in the short term instructional program based on the learning hierarchies resulted in higher scores on the Learning Hierarchies Achievement Test, but did not appear to be adequate to lead to the acquisition of the ability to perform the formal operational volume tasks. A positive correlation was found between mental age and performance on the Test of Formal Operations.

The results would also seem to support Piaget's theory of equilibration. Equilibration is the process by which a person takes in new material, fits it into a scheme of things, and alters his ideas in whatever way is necessary to assimilate the new material. This process requires time and repeated experiences. The fact that so little change in the ability to perform the task took place during the course of the short-term instruction of the study would seem to indicate that an abstract conception of volume is not developed in so short a time. Although relevant information and processes were provided they were not assimilated or equilibrated to a sufficient extent for the new concept to form

THE EFFECT OF AN EQUILIBRATED METHODOLOGY ON THE ACQUISITION OF THE CONCEPT--CONSERVATION OF QUANTITY

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The intention of this study was to contribute statistical evidence for the determination of the role of the equilibration concept in a child's transition from one stage to another in cognitive development.

The investigator attempted to develop a schematic methodology incorporating the concept of equilibration that would facilitate the transition of a child from the pre-operational stage to the concrete operational stage. Specifically, the investigator wanted to know if any equilibration based methodology could be developed which would produce a structure for the preoperational child's acquisition of the concept of conservation of quantity. In addition, would the schematic methodology be independent or dependent upon age, and also sex?

An instrument was designed by the investigator utilizing those conservation of quantity tasks that Piaget and others have found to be valid and reliable. The instrument was field tested to establish its reliability.

The equilibrated methodology consisted of activities which gave the children concrete experiences in multiple attributes, classification (multiple relations), seriation, and reversibility. It was predetermined that the methodology would be administered in five, twenty-five minute class periods.

The investigation was conducted in the latter part of May, 1968, in a private nursery school located in a small midwestern city. The children selected to participate in the experiment were between the ages of four years, three months and five years, nine months. The investigator tested each child individually utilizing the conservation of quantity instrument. The instrument was composed of a play-doh task, water task, bean task and logical operation task. Six days were utilized in pre- and post-testing the subjects. The sample consisted of 49 subjects, twenty in the morning class and twenty-nine in the afternoon class. The children were randomly assigned, within their class, to experimental or control groups.

The experimental groups (morning and afternoon) received the equilibrated methodology designed by the investigator to increase the child's conservation of quantity ability. The methodology was presented by the regular nursery school instructors, aided by the investigator.

The control groups (morning and afternoon) received their regular nursery school program with the exception that the investigator was present for these sessions.

All data were analyzed statistically and the .05 level of significance was the criterion for accepting or rejecting the null hypotheses. A 2 x 2 factorial analysis of variance was utilized to analyze the differences between the groups. The active independent variable was the equilibrated methodology of instruction. The two assigned independent variables were sex and age. The dependent variable was the gain scores on the instrument designed by the author to measure the children's performance in working with conservation of quantity tasks.

As a result of the findings of this investigation, the following conclusions were drawn:

1. Performance on conservation of quantity tasks by children in the transitional period between preoperation and concrete patterns of thought can be improved significantly by an equilibrated methodology.

2. An increase in performance on conservation of quantity tasks which is independent of age and sex can occur following instruction based on an equilibrated methodology for pre-kindergarten children.

3. The Piagetian operations of multiple classification, multiple attributes, seriation, and reversibility, can be organized into an equilibrated methodology to facilitate the acquisition of the structure for the concept of conservation of quantity by pre-kindergarten children.

ORGANIZER INFLUENCE ON CHILDREN'S ANSWERS TO QUESTIONS OF PHYSICAL CAUSALITY

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Psychologists and educators have raised a number of questions about Piaget's research. The question raised in this study is the effect of the child's perception of the interrogator on his answers. Does the child answer a causality question based upon his perception of the interrogator's attire or position in society?

In The Child's Conception of Physical Causality, Piaget describes children's statements of the cause of cloud movement. Five stages of explanations are noted: (1) Magical (We move the clouds by walking), Average age 5; (2) God or large men make them move, Average age 6; (3) The clouds move by themselves, Average age 7; (4) The wind makes the clouds move but the wind comes from the clouds, Average age 8; and (5) Correct answer, Average age 9.

The question raised in this study is - does a child's causality answer to cloud movement differ when he is faced with an interrogator whom he perceives as a priest or minister? By providing an advanced organizer such as the attire of the interrogator, does a child answer differently to a person whom he perceives as a religious leader? If such differences are evident in childrens' responses, then the mean age of the stages of causality should differ from those stated by Piaget. There should be many more stage 2 answers in older children. In addition, children being interrogated by a "minister" should show differences in causality answers when interrogated earlier or later by a "non-minister."

Four hundred children from age 4 to age 12 were interrogated by the investigators. At times the investigators wore clerical collars and introduced themselves as Father, Reverend, etc. depending on the child's religious background. Techniques similar to those described by Piaget were used to elicit student responses. Justification questions, to which the child must justify his responses were included as part of each session.

Statistical analysis will include comparison of sample average ages with those of Piaget. In addition, chi-square analysis will be used to investigate the effect of student answers and changes in student answers with "ministers" and "non-ministers."

Findings of changes in student answers with "ministers" and "non-ministers" should reflect the perception of many teachers who feel that many students view school as a place where they please teachers. On the other hand, students sticking to their explanations would corroborate Piaget's findings.

PIAGETIAN STUDIES: EFFECT OF SUB-CULTURAL PRESSURE IN QUANTIFICATION UPON TASK PERFORMANCE

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Evidence has accumulated over the past three years that within a given subculture, whether in the United States or in more primitive societies (Australian Aboriginese, Papua-New Guinea, Wolofs of Senegal, etc.), there is a lag from Piagetian (Swiss) norms for conservation ("readiness") where there is no urge to quantify in the subculture concerned. Particular subcultures cited by this research include: (1) rural vs. suburban, (2) white vs. black, (3) lower vs. middle socio-economic (SES) classification, and (4) "culture of poverty" (as defined by Oscar Lewis) and middle class homes. In addition, deLemos has shown with Aboriginals significant differences between full-blood and part-blood, but this has not been investigated in this series.

Rural vs. Surburban. Several investigators (Prince in New Guinea, Greenfield in Senegal, Goodnow in Hong Kong, etc.) have shown differences ascribed to remoteness to centers of Western contact between groups within a given culture. Matched samples of elementary school children in Northwest Ohio were tested with Piaget's tasks on quantity and weight, and the suburban sample was compared with that from a rural village. No significant differences were found. Present day mass communication media have apparently erased the differences between the "country hick" and his city cousin.

White vs. Black. Sigel *et al*. have shown that the differences between middle class white and blacks and their lower SES between-class comparater-sample were, on certain tests, greater than within-class (SES) differences, ascribing the lack of readiness in the lower SES sample to the paucity of the home environment, regardless of skin color. Using the Piaget task of "build a hotel as big as this hotel", two samples were tested, one from a black rural slum school, the other from a class in a suburban town where high and low SES children took science together in a heterogeneously-grouped class. Using Elkin's U.S.A. data for Grade 7, 8, 9 children (80% of whom conserve at CA 14), as standard for middle-class white (and confirmed in the middle-class sample herein included), it was found that only 14% of the blacks, Mexican-Americans and other low SES groups conserved at CA 14.

SES on Disjunction. Among the more difficult tests cited by Inhelder and Piaget (Growth of Logical Thinking) is the disjunction of the falling ball in an inclined plane. Data on SES, CA, sex and school grade were collected from junior high school studied, and a multiple correlation was used to show high effect of both Mental Age and SES on task attainment. Slow learners, given the same task, showed the same non-conservation shown in English studies of ESN children.

<u>Homes of two SES levels</u>. When the results of administration of Piagetian tasks using the three crucial questions (i.e., Understanding the data, making a prediction, justification of prediction) are considered with respect to home environment, the data confirm those of previous studies that (1) lower SES children fail to associate perceived picture with 3-dimensional object, hence fail in accommodation because of poor classification ability, and (2) lower SES children have less pressure to quantify in their subculture than middle class (black or white) children. Curriculum revision guide-lines for elementary and junior high school science and mathematics curricula (especially those dealing with quantification) should take these findings into account.

Session IIIb - Instruction in Biology

Chairman: James T. Robinson, Biological Sciences Curriculum Study, Boulder, Colorado.

1. "A Model for Program Selection and Its Use for Evaluating Stated Goals of Biological Science as Presented in Two Approaches: BSCS and Non-BSCS," John A. Bartos, Baldwin-Whitehall School District, Pittsburgh, Pennsylvania.

2. "The Use of Filmstrips Supplementary to Dissection in High School and College Biology Laboratories and Their Effects on Learning," Gilbert Twiest, Clarion State College, Clarion, Pennsylvania.

3. "Amount of Opportunity for Contact with Instructors in Biology Classes: Its 'Affect' on College Freshmen," Marland L. Madson, St. Olaf College, Northfield, Minnesota.

4. "An Explanation of Alternative Methods for Teaching Large Sections of General Education Biology," Paul E. Bell, The Pennsylvania State University, University Park, Pennsylvania.

A MODEL FOR PROGRAM SELECTION AND ITS USE FOR EVALUATING STATED GOALS OF BIOLOGICAL SCIENCE AS PRESENTED IN TWO APPROACHES: BSCS AND NON-BSCS

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The main purpose of this study was to develop a model which would aid a school system contemplating a curriculum change. In its structure, the model contains specifics for (1) selecting the curriculum goals, (2) identifying a program or programs, (3) implementation of the program or programs, and (4) evaluation of established curriculum goals.

The model was applied in making a curriculum decision between two biology programs, - one developed by the Biological Science Curriculum Study (BSCS), - and a conventional or non-BSCS biology, based upon a popular text. The study involved twenty-two tenth grade biology classes (597 students) of the Baldwin-Whitehall School District, geographically located in Allegheny County, Pennsylvania. The problem stated was: Is it possible through the application of a sequence of events enumerated in a curriculum-decision model to decide whether to continue the conventional biology or replace it with a new biology program?

The goals established for appraisal were: (1) to acquire adequate facts and information necessary for academic achievement, (2) to understand the method and aims of science, (3) to understand the scientific enterprise and the role of the scientists, (4) to develop problem-solving abilities, (5) to develop the process of inquiry, and (6) to provide laboratory activities.

In evaluating these program goals, nine measurement devices were used. Five of these nine were student examinations or checklist: (1) Test on Understanding Science, Form W, (2) Co-operative Biology Test, Form B, (3) Otis Quick Scoring Mental Ability Test, Gamma, (4) Biology Classroom Activity Checklist, and (5) Problem-Solving Ability Test.

Findings concerning the specification and application of the model included the following:

First, the proposal is that a committee be established to make studies of an academic course, and to make recommendations to the school concerning appropriate corrective action to be taken. In initiating a change, the committee would benefit from becoming acquainted with the policies and procedures set forth in this study.

Second, since, in effect, each school is to decide for itself what educational program is best, the study establishes that each school must review all textbooks, analyze them in terms of goals, and make a curriculum decision aided by use of the model.

Third, of primary importance is the fact that the ultimate test of implementation is in the classroom situation. Within this study, a variety of techniques were utilized to investigate the students, the teachers, and the program to determine the extent of proper implementation and the degree of goal achievement in the classroom environment. Principles described will facilitate initial committee commitments involving in-service training, lesson planning, classroom observing, and other unique characteristics of implementation.

Finally, the fourth and last component of the model was designed to evaluate six hypotheses organized around the six stated goals of biology. In the five hypotheses that were rejected, significant differences favored the BSCS biology program. The remaining hypothesis concerning the goal of inquiry was not rejected, and did not favor either program. Total inspection of the summary table resulted in the decision by the researcher to recommend to the local district that the conventional or non-BSCS biology be replaced with the new biology (BSCS). The curriculum model suggested can be followed as a general guideline for curriculum change, but must be adapted to the specifications and facilities of the local school system.

THE USE OF FILMSTRIPS SUPPLEMENTAL TO DISSECTION IN HIGH SCHOOL AND COLLEGE BIOLOGY LABORATORIES AND THEIR EFFECTS ON LEARNING

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Many new instructional materials are being produced and marketed today without being tested to determine their effectiveness. This study evaluates the effectiveness of two filmstrips used supplementary to dissection in high school and college biology laboratories.

The filmstrips "The Dissection of the Fetal Pig" and "The Dissection of the Frog" were produced by the investigator and published commercially. The filmstrips depicted actual dissections in full color with the parts of organisms labeled.

The study was carried out in five schools; two suburban, one rural, and one small town high school, and one comprehensive community college all located in the Toledo, Ohio area. In each school, two similar biology classes taught by the same instructor were used as experimental and control groups.

In the experimental class the teacher previewed the appropriate filmstrip with the students before they began dissection. During the following dissection periods students were at liberty to run the filmstrip projector and view the filmstrip. In the control section, class was conducted in the conventional manner without the use of filmstrips.

Before beginning the dissections, all students were given a pretest of anatomical knowledge prepared by the investigator. In addition, the I.Q. or aptitude scores of the students were obtained. After completing the dissection unit, students were given tests of knowledge of organ function and an anatomical recognition test prepared by the investigator. In addition, each teacher was interviewed by the investigator to determine student acceptance of the filmstrips and differences between teaching with and without filmstrips.

Individual analyses of variance were computed for each test at each school. The level of significance was set at .05 for all tests.

No significant differences were found between the experimental and control group on the pretest of anatomy knowledge and I.Q. or aptitude test scores except at the small town school where there was a significant difference in I.Q.

No significant differences were found between the experimental and control groups at any of the schools on the test of knowledge of organ functions. Significant differences were found between experimental and control groups on the anatomy recognition test at one suburban and the rural school.

Teacher interviews indicated that the students accepted and made extensive use of the filmstrips. Further, students asked fewer questions in the experimental sections because they tended to consult the filmstrips rather than the teacher.

The investigator concludes that the use of filmstrips supplementary to dissection increased students' ability to identify anatomical organs and decreased the number of student questions asked of the teacher. The use of these filmstrips or similar ones should increase the effectiveness of a teacher by providing him with a means of rapidly teaching the anatomy necessary for physiological investigations.

AMOUNT OF OPPORTUNITY FOR CONTACT WITH INSTRUCTORS IN BIOLOGY: ITS "AFFECT" ON COLLEGE FRESHMEN

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Minnesota University freshmen, enrolled in Biology 1 during winter quarter, 1969, with no prior exposure to television (CCTV) instruction were randomized into three treatment groups of 35 subjects each. Treatment A used three periods of CCTV lectures, one three-period laboratory, and one one-period discussion per week. Treatment B included "live" lectures presented by the same professors who presented the CCTV lectures, one three-period laboratory, and one one-period discussion per week. Treatment C used three CCTV lectures, one three-period laboratory, but no discussion period each week. Laboratory and discussion periods were conducted by biological science graduate teaching assistants. All subjects had lectures at the same time. Treatment B subjects had opportunities for personal contact with instructors seven periods per week; treatment A, four periods; and treatment C, three periods.

It was questioned whether the amount of opportunity for personal contact with instructors during regularly scheduled periods would affect achievement as measured by three quizzes and final examination and/or affect attitudes toward different aspects of the course as measured by semantic differentials, sixteen bi-polar adjective pairs randomized for each of five concepts, and responses to an attitude inventory of 30 randomly arranged statements. All subjects received the same quizzes, final examination, semantic differentials and attitude inventory. The semantic differentials and attitude inventory were administered at the completion of the quarter's work in biology. Thirty-three Treatment A subjects completed the course, 33 Treatment B, and 34 Treatment C.

One way analysis of variance resulted in non-rejection of the null hypothesis of equal means between the treatments (.10 level) for each of the four achievement examinations. Kuder-Richardson reliabilities for each examination for each treatment ranged from .28 to .90. Eight of the twelve reliabilities were above .65--adequate for comparison of means.

The means of the summed scores (1-7), by treatments, for each adjective pair for each concept were subjected to one way analysis of variance. Null hypotheses of equal means were rejected (.01 level) for concepts 2 and 4 (Laboratory's Contribution to Biology and Feelings About Lecturer) and rejected (.10 level) for concept 3 (Lecture Content). Newman-Keuls Means Analyses resulted in significant differences (.05 level) between treatments A and B and between B and C for Lecturer concept. There was non-rejection (.10 level) of null hypotheses associated with concepts 1 and 5 (Value and Application of Biology to My Life and College Biology Compared to High School Biology). Hoyt's reliabilities for each of the five semantic differentials for each treatment ranged

from .92 to .97.

Chi square analyses of thirty attitude inventory responses resulted in rejection of null hypothesis of equal proportions between treatments for seven of thirty statements (.10 level). Those rejected were related to laboratory or availability of assistance or professors and lectures. Hoyt's reliabilities, by treatment groups, ranged from .87 to .89.

Treatment C subjects, whose only personal contact with instructors was during the laboratory, had a more positive attitude toward the laboratory than did the other groups. Treatment B subjects, with "live" lectures, rated the lectures and lecture material more positive than did subjects in the other groups. The results indicated that the more the opportunity for personal contact with instructors the more positive the attitude toward different aspects of biology. Although there appeared to be no effect on achievement, there was an effect on attitudes as expressed using the instruments in this study.

AN EXPLORATION OF ALTERNATIVE METHODS FOR TEACHING LARGE SECTIONS OF GENERAL EDUCATION BIOLOGY

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Large enrollment courses represent the interface between pressures for more productivity by teachers and desires for more personalized instruction by students.

This project examined the effectiveness of the currently accepted three-lecture-per-week method of teaching general education biology as compared with six alternative approaches that required various reductions in weekly class attendance. Answers to the following questions were sought:

1. Will scores on achievement examinations show significant differences between the treatment groups?

2. Will scores on the Allison Science Attitude Scale show significant differences between the treatment groups?

3. Will scores on the "Course Attitude Questionnaire (CAQ)" show significant differences between the treatment groups?

4. Will attendance at review sessions vary between the groups?

5. Will the proportion of students using tape-recorded lectures vary between the groups?

One class of 400 students was divided randomly into six experimental treatment groups conforming to the following descriptions:

<u>Lecture</u>: Members of this group attended only two lectures per week and the appropriate reading assignments.

<u>Lecture-Quiz</u>: Members of this group attended two lectures and a quiz each week.

<u>Lecture-Study Guide</u>: Members of this group attended two lectures per week and were directed to answer study questions.

<u>Student Instructor</u>: Students in this treatment were assigned to small groups of six members. One session per week was devoted to training the student instructors, each of whom subsequently taught the assigned material to the other members of his group.

Seminar: Students in this group met once per week with the instructor to discuss the assigned topics.

Readings: Members of this group attended class only to take examinations. They were instructed to use the extra time for reading supplementary materials.

The control section, taught by another instructor, met for three lectures per week. Students in all groups were administered a pre-course examination, two achievement examinations during the term, and the criterion instruments at the end of the term. All students used the same textbook, followed the same course outline, and proceeded at approximately the same rate. All students were encouraged to use the tape-recorded lectures and to attend review sessions. Attendance at all sessions was recorded, but was not used as a grading criterion.

Achievement examinations were constructed cooperatively by the two instructors. The "Allison's Adaptation of the 'Allen Attitude Scale'" was used to measure the students' attitudes toward science, scientists, and scientific careers. The "Course Attitude Questionnaire" was used to examine seven factors affecting course acceptability.

No significant differences were found between the groups in scores for the pretest, second mid-term examination, the subscales or total scores for the CAQ, or the Allison scale. However, significant F values were obtained for the first mid-term examination and the final examination. The resulting t tests indicated that all experimental groups achieved significantly higher than the control section.

Students used neither the review sessions nor the lecture tapes extensively. Questionnaire responses indicated that at least 60% of the students found all methods helpful and the student seminar the most valuable. For future treatments, students showed preference for the teacher-led seminar and the lecture-quiz formats.

The results of this study indicate that student performance in large classes is not affected adversely by a reduced number of lectures. Student-instructor interaction might be facilitated through experimentations with grouping combinations made possible by the time gained from a less rigorous lecture schedule.

Session IIIc - Instructional Variables in Science Teaching

Chairman: H. Craig Sipe, State University of New York, Albany, New York.

1. "Comparative Analyses of Structure in Teacher Communicated Science Content," O. Roger Anderson, Teachers College, Columbia University, New York, New York.

2. "Assessment of Cognitive Performance in the Transfer of Scientific Processes in Biology," Bernard W. Benson, University of Iowa, Iowa City, Iowa.

3. "Demonstration of an Improved Science Curriculum for Underachieving Students (DISCUS) a Progress Report 1968-69," N. Eldred Bingham, University of Florida, Gainsville, Florida, and C. Robert Cronin, Duval County School Board, and Larry Paulk, DISCUS Project.

4. "The Development of Models to Explain the Relationship of Important Variables to Laboratory Instructional Strategies," Arthur L. White, Ohio State University, Columbus, Ohio.

COMPARATIVE ANALYSES OF STRUCTURE IN TEACHER COMMUNICATED SCIENCE CONTENT

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The organization of teacher communications was analyzed using quantitative methods derived from a general theory of structure in teaching wherein the organization of knowledge and its communication are described as serial processes based on biological and psychological principles of behavior. Two kinds of structure in teaching are presented: 1. Kinetic structure, and 2. Static structure. Kinetic structure is the serial order of discourse units (teacher statements) and their relatedness through elements (substantive terms) held in common. Static structure, the presentation of multiple associations among diverse topics occurring with high frequency in a communication, is inversely related to kinetic structure.

Empirical analyses of science teacher communications have produced three additional kinds of organizations of content called pulses, series, and symmetries. Pulses are short bursts of coherently organized communicated content and appear as one or more sharp spikes in a Kinetogram (a graphical plot of structure coefficients). Gain series are sequences of discourse units wherein the teacher progressively converges on a topic. Decay series occur when the teacher progressively diverges from a closely integrated presentation. Series are further subclassified according to their internal organization. A linear series progresses by smooth transitions from one topic to another; whereas, a pulsed series is saccadic proceeding by steps or bursts. Symmetries are sequences of discourse units containing repetition of organizations and appear in the Kinetogram as repeated identical forms of the curves. The stability and reproducibility of the Kinetogram curves were confirmed under varying conditions of lesson length and content, thus validating their use in making comparative analyses. Using operational definitions, independent transcribers have achieved 95% agreement or better in identifying discourse units.

All biology lessons analyzed thus far using Kinetograms contain distinct segments of discourse called spans. Primary spans are those enclosing other spans of discourse. Secondary spans are usually shorter sequences subsumed within primary spans or occur singly without further internal subdivisions. Tertiary and quaternary spans occur occasionally and are respectively, the third and fourth internal subdivisions contained within a primary span. The range for mean fundamental coefficients of structure in these lessons was 0.29 to 0.44. The range for mean weighted coefficients was 0.82 to 0.90. A study was performed to determine if spans of discourse units with a high mean fundamental coefficient of structure (those with high internal relatedness among pairs of discourse units) contain a higher incidence of integrating themes or topics than comparable spans of discourse units with lower mean fundamental structure coefficients. The presence of

integrating themes was determined quantitatively by assessing the relative activity of the dominant (highest frequency) verbal element (scientific term) appearing in each span. The relative activity coefficient is the ratio of the frequency count of a specified verbal element to the total number of discourse units in a span. If the specified verbal element appears in all of the discourse units in a span, the coefficient is unity and indicates the verbal element is serving as a persistent theme throughout the span. If there is little persistence of any single verbal element, the relative activity coefficient is low approaching zero. The results of this study showed there was a positive correlation between the mean fundamental coefficients of discourse spans and their relative activity coefficients. In 90% of the cases, the correlation coefficients were significantly different from zero at $p = 0.05$ or less. The range of correlation coefficients was $r = 0.44$ to $r = 0.79$. These results clearly support the principle that spans of discourse units with high mean fundamental coefficients of structure are organized around a theme; whereas, spans of discourse with low mean coefficients of structure have low specificity with reference to integrating themes. Empirical analyses of transitions between spans of discourse units yielded three kinds of transition mechanisms called couplers. Their attributes have been quantitatively defined and employed in making comparisons of the organization of teacher communications in science teaching.

ASSESSMENT OF COGNITIVE PERFORMANCE LEVELS IN THE TRANSFER OF SCIENTIFIC PROCESSES IN BIOLOGY

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This study, currently in the data collecting stage, focuses upon measuring strategies and scientific processes via a series of interrelated biological tasks. The data collecting instrument was designed to be given by personal interview to students who have completed a tenth-grade biology course. It consists of nine biological situations and a branching program. The predominant organism employed in eight of the situations is the Basidiomycete, Schizophyllum commune. Petri plates depicting each situation are presented to the student at designated times in the interview sequences.

Minimum performance levels have been established for each frame in the main sequence. Alternate pathways provide direction, focus or added information. When the minimum performance level has been reached, the next main sequence frame is presented. Qualifying frames are frequently added to clarify student responses or glean information as to why a particular response was made.

Specific criteria have been extracted from the program. In total they serve as the evaluation instrument. These criteria stated in behavioral terms are presently being classified using Bloom's Taxonomy of Educational Objectives, Handbook I: Cognitive Domain. A preliminary evaluation revealed representation in all six levels and eleven sub-levels. The criterion instrument contains 42 items inclusive of four that require the student to reserve judgment and one that employs the principle of parsimony. Some of the general behaviors required are: observations relevant to stated hypotheses or research designs, generation of hypotheses given underlying assumptions, designing experiments, recalling concepts, predicting results, explaining phenomena and discovering relationships based on observations.

Selection of students was based primarily on the BSCS Attitude Inventory (Blankenship) and the Biology Classroom Activity Checklist (Kochendorfer). This information was collected as part of a concurrent study by another investigator at the University of Iowa.

The population was limited to 1968-69 biology students of teachers enrolled in a BSCS Summer Institute at the University of Iowa during 1967. Students from four teachers were selected at random for interviewing. The students have BSCS or non-BSCS backgrounds and either a high or low mean composite rating on the above inventories. In addition, one group of students currently enrolled in BSCS biology is being interviewed.

This sampling technique was used not as a basis for comparing BSCS and non-BSCS, but primarily to achieve a representative cross-section of biology instruction. Analysis will stress nonparametric statistical procedures, i.e., chi-square and contingency coefficient with student biology background, ITED scores, and performance at each level of the cognitive taxonomy being the initial criteria. Response patterns and success at meeting criteria based on interviewer or interviewee elicitation of underlying assumptions, concepts and facts will also be assessed.

The initial full scale trial of the data collecting instrument should help elucidate the efficacy of personal interviews using this schemata when applied to biological education. It is unique in that emphasis is placed on the higher levels of cognition while a high degree of objectivity is maintained. It will also be determined if the levels of cognition required are hierarchical. With additional trials using larger samples emphasis could be shifted to comparing the effectiveness of various courses in secondary biological education relevant to the stated criteria. The problem of adapting the instrument for computer assisted instruction is also being considered.

DEMONSTRATION OF AN IMPROVED SCIENCE CURRICULUM FOR UNDERACHIEVING STUDENTS (DISCUS), A PROGRESS REPORT 1968-9

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The purpose of this study is discernible from its title "Demonstration of an Improved Science Curriculum for Underachieving Students." The investigation began with a Pilot Project in a junior high school in Jacksonville, Florida and during the past two years has been expanded to 12 junior high schools, two parochial schools, and a Boy's Parental Home. The program is presently funded through a cooperative venture of the Duval County School Board, ESEA-1, and a University of Florida Cooperative College-School Science Improvement grant (CCSS) by the National Science Foundation.

The subjects were randomly assigned to treated and non-treated groups from a population of underachieving students, identified as those having report card grades below average and IQ scores average or above average. All those pupils who would be in grades 7, 8, and 9 were considered.

The teachers of the DISCUS classes and of the non-treated groups were randomly selected from a pool of junior high school science teachers who agreed to participate in the project. Special instruction in teaching science to disadvantaged youth as well as special materials for use in the classrooms were provided the teachers of DISCUS. Twenty-eight teachers and more than a thousand pupils were in the treated groups during the 1968-69 school year, which operation is reported here.

Pretests and post-tests were administered to both the treated and non-treated groups in all three grades to determine the effectiveness of the newly developed instrumental program. The Otis Quick-Scoring Mental Ability Test (Beta Test, forms Em and Fm); the science section of the STEP test (forms 3A and 3B); and a Student Attitude Scale developed by J. A. Battle were administered to 2,050 pupils. A randomly selected sample, 178 pupils, were administered these additional tests; 1) Projective Essay--the pupils were asked to write an essay titled "What would be a teenager's advice to the school?" 2) Projective Interview--the pupils were shown pictures and asked to make up stories about the pictures. The interviews were taped.

An analysis of co-variance of the pretest and post-test results from the Battle Student Attitude Scale, the Projective Essays and the Projective Interviews revealed, among other things, as was the case in the operation during the previous spring, that the treated groups made changes too great to be attributed to chance in these respects:

1. A positive change in attitude toward self

2. A negative change in attitude toward peers

3. A positive change in attitude toward teachers

4. A positive change in attitude toward the school

In an attempt to find whether the changes were primarily a result of the effective behavior of the teachers, their cognitive or manipulative skills, or of the kind of science experiences they provided, video tapes were made in nineteen of the classrooms. These tapes were systematically observed and analyzed using:

Brown's Teacher Practices Observation Record (TPOR)

Ober's Reciprocal Category System (RCS) and

Solomon's Taxonomy of Image Provoking Behavior

It was found that the DISCUS teachers, in comparison with the other teachers, were more experimental in their teaching; that is they implemented the Dewey philosophy in their teaching; that they talked much less; that their pupils talked much more; and that their pupils spent much more time busily engaged in productive work. The DISCUS teachers used much more concrete image provoking behavior, a little less representational image provoking behavior, and much less abstract image provoking behavior. Their image provoking behavior was far less abstract than that of the other teachers.

THE DEVELOPMENT OF MODELS TO EXPLAIN THE RELATIONSHIP OF IMPORTANT VARIABLES TO LABORATORY INSTRUCTIONAL STRATEGIES

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In this study models were developed to identify the important variables and their causal relationships to the instructional strategies used in laboratory science teaching in secondary schools. Sources of data included a checklist completed by students to identify the degree of inductive-indirect strategy and the degree of expository-direct strategy used by their teachers in laboratory sessions. Questionnaires, test scores, and direct observations of laboratory activities were used to collect data on other variables.

The variables included student measures, teacher measures, administrative and environmental measures, material and content measures, and instructional measures. The intercorrelations of these variables were factor analyzed and the number of variables reduced to twenty factors which were identified and used as variables in a path analysis. The path analysis was used to postulate and test the fit of two models for the causal effects of variables on laboratory teaching strategies. The teaching strategies identified as factors from the factor analysis were Inductive-Indirect Teaching and Lecture Method.

The factors identified as causally related to teaching strategies were Instructional Load, Educational Level, Teacher Morale, Academic Preparation of Teacher, School Size, Student Attitude, Budget, and Age of Curriculum. The educational level of the students, the academic preparation of the teacher, and the morale of the teacher were characteristics common to the causal models for both Inductive-Indirect Teaching and for Lecture Method.

The results of the study included a large negative effect for the influence of Educational Level of Students on Inductive-Indirect Teaching. This would indicate that the maturity of students causes teachers to use methods other than inductive-indirect. Educational Level of Students also had a negative effect on Lecture Method. This may indicate that the maturity of students at higher grade levels causes teachers to use less Lecture Method than at the lower grade levels. Teachers in the upper grades apparently provided structured laboratory activities using written materials to direct and guide the students through prescribed procedures.

According to the models developed the lack of student maturity influences teachers to use more inductive-indirect activities that are student centered. In addition, the teachers of the lower grade levels

talk more, relying less on the students ability to read and less upon past educational experience to serve as guidance for the student. An important conclusion to be made from these relationships is that the amount of teacher talk is not a valid indicator of the degree of inductive-indirect strategy employed by the teacher in science laboratory instruction. The identification of Teacher Morale as a positive influence on Inductive-Indirect Teaching and a negative influence on Lecture Method suggests that research comparing teaching methods under laboratory conditions must make provisions for control of this teacher characteristic or results will be confounded beyond interpretation.

Concurrent Sessions IV

Session IVa - Symposium: A Hard Look at Earth Science Education Research

Chairwoman: Marjorie Gardner, University of Maryland, College Park, Maryland.

Participants: Rolland B. Bartholomew, University of Maryland, College Park, Maryland.

Daniel J. Brovey, Queens College, New York, New York.

John R. Hassard, Georgia State University, Atlanta, Georgia.

George T. Ladd, Boston College, Boston, Massachusetts.

John A. Maccini, University of Maryland, College Park, Maryland.

John P. Smith, University of Washington, Seattle, Washington.

DETERMINING THE EFFECT OF INSTRUCTIONAL MODELS ON THE INVESTIGATIVE TEACHING BEHAVIOR OF EXPERIENCED EARTH SCIENCE TEACHERS

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University of Maryland
College Park, Maryland

The purpose of this study was to ascertain if the investigative teaching behavior of experienced earth science teachers could be changed by the use of instructional models. Research questions applicable to this study were:

1. Do teachers change their investigative teaching behavior after seeing an instructional model?

2. If change occurs, which treatment produces the greatest change in investigative teacher behavior in the prelab discussion? In the postlab discussion?

3. If change occurs, which treatment produces the highest investigative ratio (IR) of teaching behavior in the prelab discussion? In the postlab discussion?

4. If change occurs, does the treatment group studying the instructional model immediately prior to teaching develop a higher investigative ratio than the group that did not see the instructional model prior to teaching?

Twenty-seven experienced earth science teachers were assigned randomly to five treatment groups. Each teacher taught the same Earth Science Curriculum Project investigation -- 17-4: Creating a Model of Radioactive Decay -- to two different groups of students in a microteaching format. Videotapes of the prelab and postlab discussions were made. Four scores were obtained for each teaching session by using a modified form of the Flanders Interaction Analysis system. These scores consisted of pretest and posttest ratings of each prelab and postlab discussion.

Research Design

	View Model	Teach	View Self	View Self and View Model	View Model and View Self	Study Written Model	Re-teach
Group 1		X	X				X
Group 2		X		X			X
Group 3		X			X		X
Group 4		X				X	X
Group 5	X	X	X				X

Teachers did change their investigative teaching style after seeing an instructional model. With the exception of Group 1 (which showed a slight negative change), all average group scores improved in the direction of the model. Group 3 showed the greatest change in the prelab discussion, and Group 2 had the greatest change in the postlab discussion. The highest investigative ratio in the "re-teach" of the prelab discussion was achieved by Group 3 and in the postlab discussion by Group 4. Group 5, having seen the model prior to teaching the prelab discussion, had an investigative ratio almost twice the average of the other four groups on the "teach" session of the prelab discussion.

The use of instructional models combined with micro-teaching has been shown to produce changes in the investigative teaching behavior of experienced teachers in the direction of the model they study. Teachers viewing a videotape playback of their lesson without additional information show little change of teaching behavior. Modification of teaching behavior of experienced earth science teachers, thus, seems to require more than just the availability of and willingness to use classroom television equipment. Educators must supply additional information to the teacher in order to bring about change in teaching behavior, and the use of instructional models seems to be one way of bringing about changes of teaching behavior in a predicted direction.

THE EFFECTIVENESS OF ADVANCE ORGANIZERS IN ACQUIRING GEOLOGIC KNOWLEDGE IN THE FIELD

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New York, New York

The objective of this investigation was to examine the effects of varying types of introductory information (advance organizer or historical introduction) on the acquisition and retention of differentiated geological phenomena found in the field environment. Ausubel's description of meaningful verbal learning was used as a theoretical framework for the study.

A knowledge pretest was used to determine the subject's ability to learn unfamiliar geological material. After studying a specially prepared passage on rock and mineral relationships, the subjects were given a multiple choice exam. On the basis of these test scores, subjects were matched and a member from each matched pair was then randomly assigned to either the experimental or control group.

Two 500 word passages differing only in content were used as a means of presenting the independent variable. These passages were read and studied for ten minutes. After reading their appropriate introductory passages, groups of five to seven subjects were taken by trained observers to seven field locations in Central Park. At each location a specially prepared passage was read by the subjects. Concrete examples at each location were available for observation. These examples complemented and illustrated the expository information. The time available for study and observation at each location was controlled by the observer.

A multiple choice exam was administered after the location visits were completed. Subjects were retested in their regular classroom one week after the field experience.

Statistical tests performed on these data suggest the following:

1) Subjects receiving advance organizing information do not show significantly greater acquisition than subjects receiving historical introduction prior to a field experience.

2) Subjects receiving advance organizing information do not show significantly greater retention than subjects receiving an historical introduction prior to a field experience.

The results of this investigation suggest that the range of applicability of the organizer technique may be limited to those instances where strictly verbal materials comprise the learning task. Where the learning task contains concrete examples of the expository information, it

is possible that the concrete exemplars, by providing potent instructional cues, are at least as effective in aiding the learner acquire information as advance organizing information. The potency of the concrete cues is explained in terms of the role they play in reducing ambiguity of meaning that may occur in the verbal exposition alone. By providing learners with concrete cues, contrasts between relevant and irrelevant criterial attributes become more explicit, and the resulting meaning more conformable to the objective content of the learning material.

It is suggested that the association between the verbal material and the corresponding concrete examples could be described as multicontextual learning (reading and observing). Such learning may have facilitated the abstraction of commonality, strengthened the generality of the resulting concept, and endowed it with greater stability, therefore reducing the effectiveness of the advance organizer. The clarity and stability of the learning task itself may have reduced any potential advantage of the organizing information.

It is possible that the clarity and precision of the verbal exposition in the learning task of this study so enhanced discriminability that any potential advantage of the organizing introduction was reduced.

AN INVESTIGATION OF TEACHER AND STUDENT BEHAVIOR IN EARTH SCIENCE CLASSROOMS

By

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The problem of this study was to develop a reliable category system for measuring classroom behavior of science teachers by systematic observation and to test the usefulness of the instrument in a field situation. In the process of field testing the instrument, two sub-problems were investigated:

1. to describe the behavior of a group of earth science teachers and to identify similarities in the patterns of their behavior.

2. to identify the relationships between teacher and student behavior on the basis of the categories and subcategories of the Science Teacher Behavior Code and the SCAN Observation System.

The study was conducted cooperatively with Mr. Joseph A. Abruscato who used the same classrooms and similar procedures to develop a student behavior instrument, the SCAN Observation System.

To develop the instrument videotapes were made of a random sample of 16 junior high school science teachers from a population of 135 teachers in Franklin County, Ohio. The tapes were scanned repeatedly and individual behaviors noted on cards. Classification resulted in four major dimensions or categories of teacher behavior: (1) Content development, (2) Management, (3) Facilitating, and (4) Classroom climate. A fifth category, Not Coded, was added to complete the system. Twenty-nine subcategories were identified and separated into verbal and non-verbal expressions of behavior for each category. Four indices of teacher behavior were developed by combining subcategories and expressing the behaviors as ratios. The indices were identified as follows: (1) Climate index, (2) Process index, (3) Interaction index, and (4) Instructional index.

A point-in-time sampling technique for observing behavior was developed. An audio signal at five-second intervals was superimposed on the sound track of the videotapes and at the signal the behavior was classified on the basis of the category system.

Inter-observer agreement and stability reliability were determined for the instrument and for each of the categories. Using the Scott Index of Inter-coder Agreement to analyze the data, observer agreement was 0.91 and stability reliability was 0.93. Observer agreement ranged from 0.61 to 0.90 for the categories; stability reliability ranged from 0.58 to 0.90 for the categories.

To field test the instrument, eight ninth-grade earth science classrooms from Richland and Franklin Counties, Ohio were videotaped on two separate sessions. At each session two sets of videotape equipment were used to record simultaneously the behavior of the teacher and a sample of students in each classroom. The behavior of the teacher was classified on the basis of the Science Teacher Behavior Code; the behavior of six students in each classroom was classified using the SCAN Observation System. The data for each teacher were converted to percentages for each of the categories and subcategories. The student data were summed to provide a figure for each of the categories of the SCAN Observation System.

Subproblem one was investigated by combining the data obtained from the videotapes of the teachers on both sessions. The teachers were described by calculating the percentage of behavior for each category and subcategory of the instrument. The identification of similarities of behavior was analyzed statistically by the Kendall Coefficient of Concordance.

To identify relationships between teacher and student behavior, one videotaping session (representing a lecture-discussion activity) was selected for each classroom. A coefficient of correlation was calculated for all possible combinations of teacher and student behavior using the Spearman Rank Correlation Coefficient.

The conclusions regarding the study were as follows:

1. A reliable and objective instrument was developed, composed of a set of mutually-exclusive categories and subcategories designed to classify science teacher behavior.

2. The Science Teacher Behavior Code was useful in classifying the behavior of teachers other than those utilized to develop the instrument.

3. The earth science teachers were observed to exhibit the following range of behaviors for the major categories: Content development (58.57-81.19%), Management (6.62-25.51%), Facilitating (6.24-22.93%), and Classroom climate (1.34-6.15%).

4. The degree of agreement among the ranks of the earth science teachers was significant for the following subcategories of teacher behavior: Content development, Management, Facilitating, and Classroom climate. The agreement among the ranks of the teachers for the verbal subcategories and the nonverbal subcategories was also significant.

5. There were 130 significant correlations (a=.1) between teacher and student behaviors. Several teacher behaviors formed patterns of correlations with aspects of student behavior.

DETERMINING THE LEVEL OF INQUIRY IN TEACHERS' QUESTIONS

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The main null hypotheses are:

(1) There will be no significant agreement between the judges as to the level of inquiry required by each category of the Smith and Meux (1960) question classification scheme.

(2) There will be no significant agreement between the judges as to the appropriateness of the proposed definition of the word inquiry as it is commonly used in the context of a classroom discussion.

(3) There will be no significant effect attributable to the inquiry level of teacher questioning on group achievement on either low or high inquiry posttest questions.

A judge's rating scale was sent to sixteen science educators throughout the United States. The scale was used to classify each category of the classification scheme as the level of inquiry required and to assess the appropriateness of the proposed definition of the word inquiry. The results of the rating scale were used by seven experienced secondary science teachers in selecting twenty-five low and twenty-five high inquiry earth science questions for use on the posttest examination.

Audiotape recordings were made of three specific classroom discussions taking place in forty ninth-grade earth science classes where an experimental curriculum was being evaluated. To determine the predominant inquiry level of a teacher's questioning, behavior transcripts of each tape were prepared and analyzed by the investigator. This analysis was combined with the class mean I.Q. (as measured by the Differential Aptitude Test) and group achievement scores on the low and high portions of the posttest examination for statistical analysis.

The statistical techniques used to evaluate the experimental data included (a) proportions, (b) Scott's reliability coefficient, (c) analysis of covariance with one covariable (I.Q.), and (d) test for homogeneity of regression.

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All null hypotheses were rejected with:

(1) The judges showing significant agreement on the (a) level of inquiry required by each category of the classification scheme (88.3 percent), (b) appropriateness of the proposed definition of the word inquiry (93.8 percent).

(2) There being a significant effect attributable to the level of teacher questioning on group achievement on both low and high inquiry questions (beyond the .001 level of confidence).

In recent years the practice of emphasizing only low level questions has been decried because they fail to elicit higher levels of thought and because they give students the impression that science is nothing but a conglomeration of facts. Considerable emphasis has been placed on searching for ways and means of developing teachers' ability to ask high level thought provoking questions, and to maintain this ability once developed. These efforts have not, however, been too successful. The questioning practices of today's teachers is not significantly different than the practices of the teachers studied in the early part of the century. A possible explanation for this failure is that the teachers are not aware of the level of cognition which their questioning can elicit in their student and its relationship to student achievement.

This research provides a refined instrument with which the classroom teacher can directly and accurately measure the level of inquiry of his questions. With this increased awareness the teacher can modify his questioning behavior and thereby change the students' conception of science and his performance.

EVALUATION OF AN AUDIO-VISUAL TUTORIAL LABORATORY SERVING COLLEGE-LEVEL INTRODUCTORY GEOLOGY

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Recent literature concerning geologic education deals with concern of educators with introductory geology courses that serve as general education for college students. Innovations have largely been restricted to restructuring of content. Little has been accomplished using self-instruction or audio-tutorial techniques for introductory geology courses.

The audio-visual tutorial program developed at The Ohio State University was evaluated during the Winter Quarter, 1969. Research was primarily concerned with providing information for curriculum improvement and program revision by obtaining data on achievement and student assessment of media and attitude toward the program. Also of concern were relationships between achievement and such variables as time-use of carrels, success in the undergraduate program, and attitude toward AVT instruction.

A number of findings related to achievement. Relative standings of students before and after weekly units remained unaffected despite the open-laboratory system. Significant gains in achievement scores were made in nearly all of the units. High gains were registered on test items related to laboratory skill development. The programmed pre-laboratory exercise was a successful innovation. On the average, 20 percent of the students were able to score above the unit posttest unit means before entering the carrels; 5 percent scored better than one standard deviation above the posttest means. Accumulated grade-point average was a good predictor of achievement in the laboratory; however, average carrel-time and attitude were not important in predicting achievement.

The semantic differential form was used successfully for determining affective responses to various media. Students generally rated movies highest and tended to rank less difficult media as more acceptable. This experimental form was most useful for examination of specific media within weekly units. Also, audiotape interviews generally supported responses made on the semantic differential form.

Nearly 81 percent of the students had a favorable attitude toward the AVT program. There was no significant difference in attitude toward the program expressed by men and women in the program. Media assessment forms recorded data which indicated attitude changes may have taken place during the quarter.

Carrel records show that demand for carrels remained high toward the end of each week and during peak hours of each day without much improvement as the quarter progressed. Attendance dropped off by 28 percent at the end of the program.

A number of specific recommendations can be made on the basis of data obtained. More single-concept films are needed in the last half of the program. More programmed pre-laboratory exercises should be designed and implemented. Revision should be undertaken utilizing information obtained from the experimental media assessment forms. Weekly laboratory time commitments should be more uniformly distributed throughout the quarter. The open-laboratory policy and provisions for self-pacing should be maintained. Further research on attitude changes should be undertaken along with studies that will determine the best possible means for securing reinforcement in the laboratory manual. Periodic evaluation of the AVT program should be instituted on a regular basis following improvements.

THE DEVELOPMENT OF A CLASSROOM OBSERVATION INSTRUMENT RELEVANT TO THE EARTH SCIENCE CURRICULUM PROJECT

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The purpose of this study was to develop a procedure for describing performances under carefully specified conditions involving a teacher, students, and a new science curriculum. The Earth Science Curriculum Project (ESCP) was selected for the study as representative of the new curricula developed by national curriculum committees.

In phase one of the study, a classroom observation instrument was developed for investigating teacher and student behaviors associated with the maintenance of an inquiry atmosphere where Earth Science Curriculum Project materials are used as a course of study. In phase two, the observation instrument was used in ESCP classrooms to determine its reliability and usefulness in describing teacher and student classroom behaviors consistent with the ESCP philosophy and objectives.

The first step in developing the observation instrument was to make a careful review of journal articles describing ESCP. The purpose of the review was two-fold: (1) to identify statements suggesting specific teacher and student behaviors expected as part of the ESCP inquiry approach and (2) to identify assertions having important implications for teaching ESCP, but not expressed in terms of specific teacher and student behavior. In addition to the journal sources and two books about inquiry (Beveridge and Schwab), examples of teacher and student behaviors were obtained from observations of an ESCP class during the 1968 summer session.

From the sources outlined above, behavioral items were written as potential indicators of one of three categories of activities: activities consistent with maintaining the inquiry atmosphere of the ESCP materials, activities neutral to the ESCP approach, or activities inconsistent with an inquiry approach. Teacher and student behaviors were then grouped into four major categories consistent with settings expected to occur in ESCP classes, i.e., developing text material, prelaboratory, laboratory, and postlaboratory discussion.

The list of behaviors was sent to seven judges selected from a list of ESCP writers and trial teachers for their evaluation as a means of determining the content validity of the items. Judges were asked to rate each item as (1) consistent with ESCP, (2) neutral, or (3) inconsistent with ESCP. Judges' ratings for each item were reduced to a median value corresponding to the categories of consistent with ESCP, neutral, and inconsistent with ESCP. Items for which the inter-quartile range of the judges' ratings was greater than that of 51% of the items with the same median value or greater than the inter-quartile range that could be expected by chance ratings were not retained for inclusion in the observation instrument.

Classroom observations based on the instrument developed for this study were made of six ninth-grade ESCP teachers in three junior high schools. Each teacher and one of his classes was observed for one 50-minute period per day for approximately two weeks. Observations were made by three teams of two observers each.

Three of the six teachers were observed for eight consecutive days for the purpose of training observers. The second group of three teachers, comprising the study group, was observed for ten consecutive days. When observations were pooled across the four classroom settings, inter-observer agreement for the 10-day observation period was P = 74%, where

$$P = \frac{\text{agreements}}{\text{agreements} + \text{disagreements}} \times 100.$$

Taking into consideration the limitations imposed by such a small teacher sample, the results were analyzed for implication in two areas, i.e., descriptions of teachers relative to ESCP and points of departure for future research.

Session IVb - Symposium: A School Developed Outdoor Natural Science Program

Chairman: Jon C. Marshall, University City School District, Missouri.

Presentors: Ronald Compton, University City School District, Missouri.

Alvin P. Sokol, University City School District, Missouri.

Henry Kaltenthaler, University City School District, Missouri.

Jennifer Heist, University City School District, Missouri.

Reactor: Don Gann, Missouri State Department of Education, Missouri.

Session IVc - Symposium: Behavioral Objectives: Less Talk, More Action

Chairman: Richard M. Bingman, Mid-continent Regional Educational Laboratory.

Participants: Addison E. Lee, The University of Texas, Austin, Texas.

Paul G. Koutnik, Mid-continent Regional Educational Laboratory.

Edwin H. Steiner, University of South Florida

William H. Humphries, Shawnee Mission West High School.

Hans O. Andersen, Indiana University, Bloomington, Indiana.

Concurrent Sessions V

Session Va - Curriculum Organization and Learning

Chairman: Clarence H. Boeck, University of Minnesota

1. "An Analysis of the Cognitive Influence of High School Chemistry Instruction on College Chemistry Achievement," Donald G. Ring, High School District #214, Wheeling, Illinois.

2. "The Effect of Post Instructional Verbal Responses to Questions of Different Degrees of Complexity," Michael Yost, Jr., Nova University, Fort Lauderdale, Florida.

3. "A Study of Distributed Versus Massed Practice in Human Anatomy and Physiology Instruction in a Collegiate Program for Student Nurses. Phase II, Retention," Beverly White Miller, Mary Manse College, Toledo, Ohio.

4. "The Development and Use of a Learning Environment Inventory," Gary J. Anderson, McGill University, Montreal, Quebec.

5. "The Use of Visual Advance Organizers for Learning Earth Science Concepts," Joseph S. Weisberg, Jersey City State College, Jersey City, New Jersey.

6. "A Science Skill Center Approach to Develop Functional Literacy Among Socially Disadvantaged Youth," David Vitrogan, Yeshiva University, Brooklyn, New York.

AN ANALYSIS OF THE COGNITIVE INFLUENCE OF HIGH SCHOOL CHEMISTRY INSTRUCTION ON COLLEGE CHEMISTRY ACHIEVEMENT

Donald G. Ring
High School District #214
Wheeling, Illinois

The purpose of this study was to analyze high school chemistry instruction in terms of its effect on facilitating learning in college chemistry. The study focused on selected cognitive variables which could be related to the model of meaningful verbal learning developed by David P. Ausubel. A second concern of the study was to compare the modern and conventional high school chemistry programs on achievement in college chemistry.

The design of this study conforms to Ausubel's long term transfer paradigm. The subjects for the study consisted of 1,780 students taking first year chemistry at Cornell University. The subjects were administered an exam previous to college chemistry instruction. The purpose of the exam was to determine the students cognitive structure in terms of orientation toward facts and subsumers. A questionnaire was administered near the end of the first semester which determined the fact or subsumer orientation of the subjects' high school instruction. College achievement was measured by course examinations, quizzes and laboratory grades. All of the data was collected during the fall semester of the 1968-69 school year.

Among the findings were the following:

1. For most individuals, the relative levels of factual and subsumer knowledge were the same.

2. Students who had high school chemistry developed a cognitive structure at a level significantly higher than that of students who never had high school chemistry.

3. The amount of relevant factual information and organizing concepts (subsumers) within the cognitive structure of the learner was positively related to the amount of new material he was able to assimilate.

4. There was a significant interaction of fact and subsumer scores on achievement. Students who possessed high subsumer and low fact scores had higher achievement than students who possessed a large number of facts with a low number of subsumers. Very high achievement was characterized by students who possessed a large number of subsumers as well as a large number of facts.

5. Students from the CHEM Study program enrolled in a higher level college chemistry course, more frequently selected a science related major, and found high school chemistry more beneficial to college chemistry, but did not enjoy high school chemistry more than conventionally taught students.

6. CHEM Study students possessed a larger number of facts than conventional students. When college instruction required the re-learning of previously learned material CHEM Study students had higher achievement than conventional. When college instruction required new learning CHEM Study students did not achieve significantly higher than students taught by conventional methods.

7. CHEM Study students consistently taught by subsumer methods of instruction had higher achievement, fact and subsumer scores than conventional students consistently taught by factual presentation methods.

On the basis of data obtained in the study, the following conclusions were developed:

1. In general an individual's cognitive structure is characterized by similar levels of differentiation and organization. The learner's ability to process information results in the retention of similar amounts of organizers and facts relatable to cognitive structure.

2. There was clear evidence to support the position that the existence of a relevant cognitive structure facilitates the learning of new material. The amount of organized information which a learner can relate to the material to be learned significantly determines how well he is able to assimilate the new material.

3. As facts become organized into cognitive structure by the presence of subsumers their ability to facilitate new learning is greatly increased.

4. The instructional similarity of the modern and conventional high school programs results in the no difference result frequently found in comparisons. When the modern programs are taught using organizing principles they improve the level of cognitive structure attained by the students.

The most important meaning of this research is its implications for the relevance of cognitive structure on the learning of new material. The study supports Ausubel's position that the greatest single influence on learning is the amount of relevant information which is brought to bear on the new experience. The finding that the organization of information significantly effects its transfer value implies that effective curriculum must be built around stable concepts which can be easily incorporated into the learner's cognitive structure and have large "anchoring" power for the subsumption of new information.

THE EFFECT ON LEARNING OF POST INSTRUCTIONAL VERBAL RESPONSES TO QUESTIONS OF DIFFERENT DEGREES OF COMPLEXITY

Michael Yost, Jr.
Nova University
Fort Lauderdale, Florida

The purpose of the study was to determine the effect on the learning of science subject content by having students make verbal responses to questions of different complexities following sequential segments of instruction. Learning was assessed in terms of the science subject content directly applicable to the interposed questions (relevant content) and that which was not applicable to the interposed questions (incidental content).

The objectives were (1) To determine whether there is any relationship between the complexity of questions producing student verbalization and student achievement on relevant and incidental subject content when reading ability in science content is controlled for, and (2) To determine whether there is a relationship between the number of errors made in verbal response to questions of differing complexities and student achievement on incidental and relevant subject content.

One hundred and ninety seventh grade junior high school students were randomly placed in five groups. Four groups received various combinations of treatment (questions of definable complexities) and training and one group (a control) received neither treatment nor training. Tests were developed to measure student achievement on relevant and incidental subject content. The analyses utilized orthogonal polynomial constrasts in a trend analysis and multiple linear regression equations.

It was concluded from the data analysis that the two objectives were supported in the positive direction. That is, as the complexity of questions to which students responded following segments of instruction increased, student achievement on relevant and incidental science subject content also increased. And, students who responded to complex questions made more incorrect responses than students responding to less complex questions. Collectively, these outcomes indicated that students learned more when asked more complex questions following science instruction even though they had a tendency to make errors in their responses.

Although classroom teachers use questions as a tool to assist students in their learning process, no complete guidelines have been developed that indicate the effect of the complexity of questions on learning. The results of this study are a step towards establishing the effect of questions of measurable complexity on learning. Thus, the study has implications for the classroom teacher. In addition, it will be a contribution to the accumulated knowledge of learning theories.

A STUDY OF DISTRIBUTED VERSUS MASSED PRACTICE IN HUMAN ANATOMY AND PHYSIOLOGY INSTRUCTION IN A COLLEGIATE PROGRAM FOR STUDENT NURSES, PHASE II, RETENTION

Beverly White Miller
Mary Manse College
Toledo, Ohio

Phase I of this research project was reported at the 1968 annual meeting of NARST. A study had been done to determine the significance of difference in achievement in learning concepts of human anatomy and physiology in a collegiate course for student nurses when massed and distributed practices were used in curricular organization. The course involved in the study was a six semester-hour course in human anatomy and physiology offered at Mary Manse College, Toledo, Ohio, for three affiliated schools of nursing, two of whom were included in the experiment.

One Group, A, completed the course in one semester of sixteen weeks. The second Group, B, distributed the course over a two-semester interval of thirty-two weeks. These students had similar clinical classes and service in their respective hospitals during this interval.

The experimental course was organized around the nine systems of the human body with the division approximating sixty percent physiology and forty percent anatomy. The course contained two hours of laboratory experience for each two hours of lecture. All lecture sections were taught by the author, with the laboratory sections divided between two other instructors who handled students from both groups in maximum sections of twenty-four pupils. The course included identical materials.

The students from Groups A and B were similar in high school achievements, socioeconomic backgrounds, and age. The nursing schools involved selected their applicants from the upper third of secondary school graduating classes.

Samples of 35 subjects from Group A (N=42) and 75 from Group B (N=81) were randomly selected for the analysis of data gained from the administration of two tests. An initial inventory of knowledge was made by means of a pretest of 75 items covering the basic concepts of the course and composed by the author in a manner similar to the final evaluative instrument. The test was found to have a reliability coefficient of 0.76 according to the Kuder-Richardson Formula 21 for internal consistency. The final achievement was measured using the National League for Nursing Standardized Test for Achievement in Anatomy and Pysiology, Form A. This instrument was revised in 1964 and reported by the League to have a reliability coefficient of 0.88.

A comparison of the means of the two samples on the pretest, using a t test of significance of difference between means, indicated that no significant difference existed between Groups A and B in initial knowledge. The use of the same statistical device in comparing the two groups on the NLN test for final achievement indicated a difference between means that was highly significant at the 0.001 level in favor of the distributed practice of two semesters.

Phase II of the study dealt with the ultimate retention of knowledge in the area after a succeeding two year period of diploma training and clinical classes. The subjects from Group A sample of 35 were reduced to 27 and the 75 from Group B to 65 by marriage, change of profession, or move out of the state. None left because of academic difficulties.

Those remaining of the initial samples were again measured by the same form of the same test at the end of the subsequent two-year period of training. A comparison of the two means, using a t test of significance of difference, still indicated a significant difference between the two groups in regard to retention at the 0.001 level in favor of the distributed practice of two semesters.

Furthermore, comparison with a t test of the means of Group A in initial achievement and subsequent retention two years later indicated no significant difference between final achievement mean and subsequent retention mean. The final two years of clinical experience and diploma training are apparently effective in sustaining knowledge gained from the preclinical year, but do not alter the level of achievement significantly over the initial level attained, in spite of the fact that the two clinical years contained different hospital experiences and variations in the class arrangement at the two diploma schools.

THE DEVELOPMENT AND USE OF A LEARNING ENVIRONMENT INVENTORY

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The central problem was to determine the feasibility of developing a non-observational student-centered measure of classroom interaction for use in high school physics classes. Three years of research with Harvard Project Physics resulted in a reliable and valid inventory which taps student perceptions of 14 social climate dimensions of their class. Pupils respond to statements which describe classes in general by signifying whether or not each statement describes their class. Data from over one thousand pupils indicated that it was possible to construct scales that had satisfactory levels of internal consistency of response and that at the same time produced adequate agreement among the members of a class.

Several studies related scores on the inventory to such variables as student characteristics, class size and composition, teacher personality and experience with a particular physics course, as well as the structure of the course being used. These investigations have demonstrated various aspects of construct validity by supporting a number of hypotheses about anticipated relationships. More crucial, however, were studies which attempted to predict learning from the social climate characteristics of the classes themselves. The first of these studies was presented at NARST two years ago. The remainder of the paper will focus on the latest of these attempts to account for student learning in terms of the social climate characteristics of physics classes.

Eight separate same-sex samples containing a total of 1,077 high school students were selected at random from among the pupils in 113 classes which used the Harvard Project Physics course during the 1967-1968 school year. Step-wise multiple regression analysis with product and quadratic terms was employed to relate characteristics of classes to residually-adjusted measures of learning for individuals within them.

Four of the established relationships are considered most relevant for the teacher and researcher. These will be discussed in some detail and related to prior investigations in this area and to plans for further research in 1969-1970.

The intimacy, or cohesiveness, of the class interacted with student ability for females, confirming a prior hypothesis -- class intimacy was positively related to learning for high-ability females,

while for girls of lower ability, a negative relationship occurred. Highly intimate groups have strong norms which encourage learning for highly intelligent and presumable learning-oriented females, but act against achievement for girls of lower ability.

Friction, or hostility among students, bore non-linear relationships to learning for girls such that extreme class scores on friction led to greater understanding of science than moderate levels of friction. The results were interpreted in terms of the cooperation-competition dimension. Cooperation (low friction) seems to promote achievement learning for students of low ability, while competition (high friction) tends to be associated with achievement learning for the highest ability levels.

Greater learning occurred for individuals in classes rated as highly difficult than for those in less difficult classes. Possibly, students in such classes increase their efforts out of a fear of failure. In one sample, pupils in classes of middle difficulty gained more than those in environments with more extreme difficulty.

The extent of cliqueness in the class tended to be negatively related to learning for males, but interacted with ability for females. Contrary to the findings for boys, girls of low ability gained most in classes where cliques occurred. These cabals, as such groups are called, enable those highly interested and motivated girls who elect a course in physics to support one another in their study of a "masculine" subject. For boys who have less interest in science, however, cliques provide a means of escaping academic responsibilities.

THE USE OF VISUAL ADVANCE ORGANIZERS

FOR LEARNING EARTH SCIENCE CONCEPTS

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Recent research by David P. Ausubel has established the use of advance organizers as one method of structuring highly generalized and abstract information as an introductory verbal passage which precedes the more detailed and specific material in a new learning task. This research was designed to determine whether other advance organizers in the form of visual aids might serve the same function as Ausubel's verbal advance organizers.

The experiment was designed to test the following null-hypotheses at the 5 per cent probability level:

1. There are no significant differences among the mean achievement scores of students exposed to various types of advance organizers. The specific types of advance organizers all have a similar effect on learning by the students in the study.

2. There are no significant differences among the mean achievement scores of students place in high, middle, and low categories of prior knowledge. All groups perform equally well with the various types of organizers used in the study.

3. There are no significant differences among the mean achievement scores of students grouped by sex. Girls perform as well as boys at this grade level in all categories of prior knowledge and treatment.

4. There are no significant interactions between scores of prior knowledge and the type of organizer presented to the students.

The basic design of the study consisted of a 4 x 3 x 2 ANOVA factorial design. Ninety-six eighth-grade students were assigned four to each of the twenty-four cells based upon treatment, sex, and prior knowledge determined by a pretest of forty multiple-choice questions. One group was exposed to a physiographic diagram of the North Atlantic Ocean Floor. A second group was exposed to a topographic profile of the North Atlantic Ocean Floor. The third group read a five hundred-word passage dealing with the same information as was covered on the other advance organizers. A fourth group functioned as a control group. All

students worked with the writer outside of the classroom on an individual basis. Following the examination of the organizers, all students read a 1,100-word new learning task dealing with continental drift which used ocean floor features as illustration of the theory. All students were then given a parallel form of the pretest. The correlation between the two tests was 0.84, as determined on the basis of a trial phase using a similar population.

The first null-hypothesis was rejected by the results obtained: there was a significant difference between map or graph organizers and the verbal organizer.

The second null-hypothesis was also rejected. Students grouped into categories of high, middle, and low prior knowledge showed significant differences in improvement with all types of organizers.

The third and fourth null-hypotheses were not rejected. Both sexes did equally well on all treatments and no interactions of any significance were found between treatment and prior knowledge categories.

A SCIENCE SKILLS CENTER APPROACH TO DEVELOP FUNCTIONAL LITERACY AMONG SOCIALLY DISADVANTAGED YOUTH

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A Science Skills Center was designed and operated as part of an NDEA Summer Institute for Teachers in Grades 6-9, in which 40 teachers participated. These teachers were provided with the opportunity to participate in demonstration centers working with some 90 children, whose reading scores ranged from 3.0 to 8.5, ranging in age from 11 to 14 and attending lower Manhattan schools. Thirty of these children worked in the Science Skills Center, ten from the top third, ten from the middle third, and ten from the lower third on the basis of their pretest reading scores on the California Achievement Scale. These children also worked in Reading Skill Centers, which were designed as learning laboratories where children work individually, or in small groups, interacting with self-directing materials which are matched to diagnosed needs. The Science Skills Center, thus, provided thirty children to engage in self-directing, and self-correcting learning experiences which integrated reading with highly motivating science experiences through laboratory experiments. These experiments provided the children with a concrete meaning for words which were involved in the experiments, and provided the opportunity to learn science concepts and processes. Feedback for self-correcting was provided by means of a perceptual check on whether a solution for the science problem posed was obtained.

Peer-to-peer teaching was anticipated and encouraged, so that the children in the upper third reading level assisted those in the lower third in reading and carrying out instructions. Language arts experiences were structured upon science activities which the children initiated and carried out. Objectives of each experiment, mostly in the physical sciences, were discussed with the participating teachers, who then cooperated in writing the activities to develop and achieve the objectives.

The children showed remarkable achievement in terms of the enthusiasm with which they responded to the various tasks in which they were involved, giving inspiration and encouragement to the participating teachers of the effectiveness of a science skills center in developing functional literacy among poor readers. In addition to demonstrating that they understood the science concepts involved through the successful completion of the science problems which were posed, definite gains in reading were obtained on posttests on the California Scale. It was found that the top third showed a gain of 0.6 of a grade, the middle third showed a gain of 0.5 of a grade, and the lowest third showed a gain of 0.4 of a grade. Further factors of achievement can be gleaned from the reports which they made in writing and drawing concerning the science experiments which they carried out.

This experience has implication for the teaching of science to poor readers and underachievers, as well as to the teaching of science to all children creatively.

Session Vb - Instructional Techniques in Science

Chairman: Joseph D. Novak, Cornell University, Ithaca, New York

1. "Evaluation of Student Laboratory Reports Under a Schedule of Partial Reinforcement," Ronald D. Cohen, Claremont University Center, Claremont, California.

2. "An Experimental Study of the Use of Programmed Instruction in a University Physical Science Laboratory," Marjorie R. Barnes, Ypsilanti, Michigan.

3. "The Correction of General Science Misconceptions as a Result of Feedback Mode in Computer-Assisted Instruction," David Alan Gilman, Ivan Hernandez, and Roberta Cripe, Indiana State University, Terre Haute, Indiana.

4. "An Investigation of the Relationship Between Selected Psychological Characteristics of Students and Performance in an Audio-Tutorial Genetics Program," Harry O. Haakonsen, Southern Connecticut State College, New Haven, Connecticut, and A. T. Collette, Syracuse University, Syracuse, New York.

5. "Programmed Instruction in Human Reproduction at the Tenth Grade Level: A Study of the Relationships Between Comprehension and Selected Student Characteristics and Family Factors," Robert H. Reeve, Indiana State University, Terre Haute, Indiana.

6. "Construction and Evaluation of Certain Modules in a Programmed Course in Astronomy Using Multi-Media Techniques," Robert B. Collagan, Morgan State College, Baltimore, Maryland.

EVALUATION OF STUDENT LABORATORY REPORTS UNDER A SCHEDULE OF PARTIAL REINFORCEMENT

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This investigation tested the hypothesis that there would be no difference in the number of acceptable laboratory reports submitted by students in a ninth grade science course under a schedule of continuous reinforcement where the teacher graded every report, as compared to the number submitted under a 25 per cent variable-ratio partial reinforcement schedule where the teacher graded only one out of every four laboratory reports submitted by students.

A 2 x 2 counterbalanced quasi-experimental design was used with two groups of 48 students during an 18-week period for 16 reports. An acceptable level of acquisition in the writing of laboratory reports was maintained under a continuous reinforcement schedule for 8 reports with both groups. Students were then informed of a "new grading procedure." For one group the teacher graded only one randomly selected laboratory report out of a set of 4 for each student, the other 3 reports being returned at the same time without any comment or grade except the fact that they were acceptable. The students in the other group submitted reports under a schedule of continuous reinforcement. The reinforcement schedules were then interchanged with both groups for another set.

Utilizing a chi-square 2 x 2 fold contingency test with Yates' correction for continuity, no significant differences were found between the two groups with respect to a continuous reinforcement schedule of a 25 per cent variable-ratio partial reinforcement schedule as measured by the number of acceptable student laboratory report responses ($\underline{X}^2 = 0.1138$, 4 d.f., p. $\angle$.995).

The results agree with previous empirical findings that fewer responses can be required under a partial reinforcement schedule to maintain a level of performance approaching or equaling a continuous schedule of reinforcement. However, most prior research was concerned with the effects of partial reinforcement on animal behavior, few studies were related to human behavior, and no empirical findings were reported in terms of complex student behavior in an actual classroom situation.

Several implications of this grading procedure will be discussed, among these the fact that it allows the teacher to assign an optimal number of laboratory reports without creating an overburdening evaluation task, yet at the same time exposing students to an evaluation situation which resembles the work environment they will encounter after formal schooling.

AN EXPERIMENTAL STUDY OF THE USE OF PROGRAMMED INSTRUCTION IN A UNIVERSITY PHYSICAL SCIENCE LABORATORY

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The purpose of this study was (1) to design, develop, and evaluate programmed instructional materials which could be used in university physical science laboratory classes, and (2) to compare the use of these materials with the use of conventional materials.

The subjects were all of the students enrolled in two similar freshman-level physical science general education classes at Eastern Michigan University in the fall semester, 1966. Students in both courses were assigned the same series of seven laboratory investigations. Six laboratory sections used programmed laboratory instructional materials prepared by this writer (Experimental Group, N = 105), and six sections used the narrative-form workbook which had been used traditionally (Control Group, N = 109).

Programs were prepared for four of the investigations, the subject matter being that which was introductory to data collection. Laboratory procedures, per se, were not programmed, but were included in the printed materials. Programs were written to behavioral objectives of the investigations, using a linear paradigm with a combination of constructed and discrimination responses. During development, programs were tried out on individuals, edited by subject matter and programming consultants, field tested, and revised, as seemed to be necessary to effect learning.

Scores on a pretest, the Physical Science Test, and on the Scholastic Aptitude Test (SAT) were used as initial measures. Final measures included: scores on the Physical Science Test as a posttest, laboratory performance examination (Labtest) scores, laboratory grades, and course grades. Questionnaire responses supplied opinions of Experimental Group students toward programmed and conventional materials; laboratory instructors were interviewed for their opinions. The twenty-four-item multiple-choice Physical Science Test had been developed previously by the course lecturer. The five-problem Labtest, developed for this study, sampled the attainment of laboratory objectives. Students were required to perform laboratory operations to obtain data for determining specified values.

The major hypothesis, that there were no significant differences between the Experimental and Control Groups, was separated into several null subhypotheses based on course, sex, and ability (SAT levels) for each of the initial and final measures. Analysis of variance and t ratios tested the significance of the differences between the means of the various groups and subgroups on all measures. The major hypothesis was accepted because nearly all subhypotheses were accepted. All subhypotheses for pretreatment comparisons were accepted, as were nearly all subhypotheses for posttreatment comparisons. Rejected posttreatment subhypotheses concerned scores on the total Labtest and on two Labtest items.

On the questionnaire, three-fouths of the students in the Experimental sections expressed a preference for programmed materials over conventional materials for laboratory preparation, and two-thirds of them found programmed materials easier to understand. Laboratory instructors found that Experimental Group students were better prepared for laboratory activities than were Control Group students.

It was concluded that (1) students achieved equally well in physical science written evaluation measures and in laboratory performance whether they used programmed laboratory instructional materials or conventional materials; (2) students with higher ability levels tended to have more success in physical science course and laboratory work than did those with lower abilities; (3) both students and instructors preferred programmed to conventional materials; and (4) programmed materials prepared students better for laboratory activities than did conventional materials.

It was recommended that (1) properly prepared and developed instruction should be used more frequently than at present for preparing university students for laboratory activity (such usage would not preclude employing open-ended, discovery, or inquiry methods--programs could provide any needed information for background or procedures); (2) training of physical science teachers should include methods of designing, developing, and evaluating programmed materials; and (3) performance examinations should be included in the evaluative measures of science courses having laboratory activities--whether programmed materials are used or not.

THE CORRECTION OF GENERAL SCIENCE MISCONCEPTIONS AS A RESULT OF FEEDBACK MODE IN COMPUTER-ASSISTED INSTRUCTION

David Alan Gilman
Ivan Hernandez
Roberta Cripe
Indiana State University
Terre Haute, Indiana

Feedback and knowledge of results are considered to be important factors in programmed learning and computer assisted instruction. Prior studies in programmed learning have not been able to compare the effectiveness of the several modes of feedback in correcting student errors because these studies utilized low error rate linear type programs. Since few incorrect responses are made by a student learning by means of a linear type program, little is presently known concerning how feedback can be used to correct student errors.

The adjunct auto-instruction techniques developed by Sidney Pressey do not necessitate a low error rate program and thus provide a better means for investigating the use of feedback to correct learner errors. This study is a replication of an earlier study by the senior author, except that in the present study, a faster instructional terminal was used and delayed retention was measured.

This study investigated three questions regarding feedback in a computer assisted adjunct auto-instruction program:

1. Does feedback mode have an effect on original learning?

2. Does feedback mode have an effect on immediate retention?

3. Does feedback mode have an effect on the amount of time required for instruction?

Seventy-five university upperclassmen were taught 30 general science concepts by means of a computer assisted adjunct auto-instruction program. The frames of the program were multiple-choice items dealing with general science concepts. One response to each item was a correct response, one response to each item was a common misunderstanding of the concept, and the other two responses were reasonable and plausible distractors.

Equipment used was a Didactor, solid state computer, DTR 300, equipped with touch-tone terminals, 35mm film, timed interface and sequence presentation. The treatment groups differed only with regard to feedback modes. The five modes of feedback compared were (Group A) no feedback, (Group B) feedback of "correct" or "wrong," (Group C) feedback of the correct response choice, (Group D) feedback appropriate to the student's response, (Group E) a combination of the feedback modes of Groups B, C, and D.

Ss were assigned to five strata on the basis of scholastic aptitude. The twenty Ss in each strata were randomly assigned to one of the five treatment groups. A treatment x level analysis of variance was performed to determine whether differences existed between any of the treatment groups with respect to any of several variables tested. Tukey's W-Procedure was used to ascertain if differences existed between specific pairs of means.

The means of the five treatment groups were not significant ($p > .05$) with regard to SAT scores, pretest scores, or the time required for the Ss to attain the criterion of thirty correct responses.

The means of the knowledge of correct response group (Group C) and the combination of feedback modes group (Group E) were significantly better than the other groups with respect to the responses to attain criterion on Trial 1. Group B (the knowledge of results group) was significantly better than the no feedback group ($p > .05$) with respect to the number of responses required to attain criterion on Trial 1.

The means of groups C and E were also significantly better ($p < .01$) than the other groups in terms of the number of responses required to attain criterion on Trial 2, with the exception that there were no significant differences between Groups C and A.

Posttest results indicate better immediate retention ($p < .01$) in terms of number of correct responses on Trial 2 for Group E over all other groups. Group C was also significantly better than Groups B and D on number of correct responses on the posttest.

Delayed retention data is presently being analyzed.

Apparently the most significant factor in the rate of correcting misconceptions by CAI is guiding the S to the correct response. The most significant factor in immediate retention is the amount of feedback information or the bits of information the student receives.

AN INVESTIGATION OF THE RELATIONSHIP BETWEEN SELECTED PSYCHOLOGICAL CHARACTERISTICS OF STUDENTS AND PERFORMANCE IN AN AUDIO-TUTORIAL GENETICS PROGRAM

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It was the purpose of this study to investigate the relationships between selected psychological characteristics of students and performance in an audio-tutorial genetics program at Syracuse University. The research design utilized multiple linear regression analysis to determine the ability of cognitive predictors (Cooperative School and College Ability Test and Fluency Test scores) to account for the variance in the criterion (summated achievement scores) for the A-T course. Further analysis attempted to discover if the addition of personality factors (Stern's Activity Index Scores) to the cognitive predictors would result in a statistically significant increase in predictive efficiency. Since sex was shown to be related to academic achievement, it was incorporated as a predictor in all prediction equations. Similar regression procedures were used to determine the ability of cognitive predictors and personality factors to account for the variance in student attitude scores.

Since the development of a positive attitude toward genetics and audio-tutorial instruction was deemed to be important, an effort was made to delineate student attitudinal reactions to A-T genetics and its components. On the basis of evidence collected in this study, it would appear that students generally prefer the A-T mode of instruction to the traditional lecture-recitation approach. Student reactions to the A-T system suggest that:

1. A-T instructional systems provided students with more personal attention than they generally receive in lecture-recitation courses of similar size.

2. A-T instruction was an efficient and effective method for teaching elementary genetics.

3. Instructional objectives for the course and the instructional units were clearly defined.

4. The A-T system provided for individual differences in background and learning style.

5. Students enjoyed the flexible design of the A-T program.

6. Students appreciated the opportunity to set their own pace through instructional sequences.

7. Students in general enjoyed the A-T genetics program and would recommend that the system be maintained.

With few exceptions, the elementary genetics students had positive attitudes toward the A-T genetics program and felt that it was an effective and efficient method for presenting this type of course.

In predicting student achievement in A-T genetics, the cognitive predictors were of most value, accounting for 38% of the variance in student achievement scores. The addition of student personality characteristics to the regression equation predicting achievement did not significantly increase the multiple R. This may be a reflection of the ability of the A-T format to meet the needs of students with divergent personality profiles. Cognitive and affective factors were not effective in predicting student attitude toward A-T genetics. This might well be a reflection of the flexibility of the branching format of the audio-tutorial course.

On the basis of this research, it would appear that student achievement in audio-tutorial genetics can best be predicted by using a multiple regression incorporating the following factors:

1. SCAT-Q scores

2. Sex of the student

3. Word Fluency scores

4. Dependency Needs scores

5. Ideational Fluency scores

6. SCAT-V scores

These factors constitute the best predictors derived from the full set of predictor variables.

PROGRAMMED INSTRUCTION IN HUMAN REPRODUCTION AT THE TENTH GRADE LEVEL: A STUDY OF THE RELATIONSHIPS BETWEEN COMPREHENSION AND SELECTED STUDENT CHARACTERISTICS AND FAMILY FACTORS

Robert H. Reeve
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In a previous study this investigator found significant relationships between junior high school students' comprehension of a programmed textbook, The Biological Concepts of Human Reproduction, and the students' characteristics of mental ability, grade level, and sex. The results indicated that mental ability was the only variable that significantly affected comprehension of the programmed textbook.

In the Spring of 1969, this investigator conducted another study utilizing the same programmed textbook, The Biological Concepts of Human Reproduction. The purpose of this study was to determine the relationship of comprehension of the programmed material by tenth grade students to selected student characteristics and family factors.

The criterion pretest was administered to 133 public high school students in their regular health classes. Each student worked through the programmed textbook individually. The criterion posttest was administered immediately upon each student's completion of the textbook.

The five student characteristics investigated were: age, sex, educational program, reading ability, and mental ability. The eight family factors were: male or female as head of household, occupation of head of household (professional, skilled, unskilled, unemployed), living with natural parents or with parent substitute, mother or mother substitute employed or full-time homemaker, younger sisters, older sisters, younger brothers, and older brothers. The information regarding these student characteristics and family factors was taken from the students' cumulative records. These data and the criterion test scores were then analyzed.

In order to determine the statistical significance of the relationships between students' comprehension of the programmed textbook and the student's characteristics and family factors at the .05 probability level a stepwise regression analysis was used for the quantitative variables and a repeated measures analysis of variance with blocking for qualitative variables.

Mental ability and reading ability were the only students' characteristics that were significant. In fact, they were very significant ($p < .001$) and indicated that the higher the ability the higher the comprehension.

Three family factors were significant: older brothers ($p < .001$), occupation of head of household ($p < .01$), mother or mother substitute employed or full-time homemaker ($p < .05$). The presence of older brothers in the home, the more skilled occupation of the head of the household, and the presence of the mother (or mother substitute) as a full time homemaker contributed significantly to students' comprehension of the programmed textbook.

This study indicates, as did the previous study with 7th, 8th, and 9th grade students, that individuals with higher ability, especially higher reading ability, respond better than those of lower abilities to verbal types of programmed materials. To be more effective for lower ability students programmed materials should have more visualization and, perhaps, even be supplemented with audio materials.

The family factors that were significant, older brothers in the home, occupation of the head of the household, and the presence of the mother or mother substitute as a full time homemaker indicates a need to investigate more thoroughly those factors in the home environment which affect the quality and extent of learning in the classroom. This type of inquiry into the effect of family factors on classroom instruction should not be restricted to human reproductive education. It is possible that the family environment influences all classroom instruction to a greater extent than has ever been realized.

CONSTRUCTION AND EVALUATION OF CERTAIN MODULES IN A PROGRAMMED COURSE IN ASTRONOMY USING MULTI-MEDIA TECHNIQUES

Robert B. Collagan
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The object of this research has been to develop, through the use of educational technology, "hardware" and software; and to evaluate the first track (i.e. nontechnical) of a proposed Space Science course currently being prepared for Goddard Space Flight Center personnel. The research this year has been confined to the major area of the program tentatively entitled "The Vastness of the Universe." By means of written programmed materials, films, film loops, film strips, videotapes, audiotapes, etc., the specific topics dealing with time, space, and matter models of both our solar system and our galaxy have been constructed and are being evaluated.

Innovative multi-media techniques involving the following specific concepts have been developed: the nature of scale models; the solar system-size, distance, and organization; the galaxy - distribution and organization of stars; beyond the milky way.

Control and experimental groups, based on a matched-pair technique have been formed to test the new auto-instructional materials and results and conclusions should be available prior to the 1970-1971 academic year.

Session Vc - Symposium: Approaches to Science Teacher Behavior Assessment and Modification

Chairman: Earl J. Montague, University of Texas, Austin, Texas.

Speakers: Robert G. Bridgham, Stanford University, Palo Alto, California.
John P. Smith, University of Washington, Seattle, Washington.
Bruce A. Kaiser, Portland State University, Portland, Oregon.
Gene E. Hall, University of Texas, Austin, Texas.
John J. Koran, Jr., University of Texas, Austin, Texas.

Discussants: Frederick J. McDonald, New York University, New York, New York.
Addison E. Lee, University of Texas, Austin, Texas.

Concurrent Sessions VI

Session VIa - Evaluation in Teacher Training Programs

Chairman: Robert W. Howe, Ohio State University, Columbus, Ohio.

1. "Role Playing as a Technique for Developing a Scientific Attitude in Elementary Teacher Trainees," Earl F. Hughes, Nova University, Fort Lauderdale, Florida.
2. "Attitudes and Attitude Change: It's Influence Upon Teaching Behavior," Helen H. James, University of Colorado, Boulder, Colorado.
3. "A Comparison of the Effects of Observational Learning and Self-rating on the Acquisition and Retention of a Questioning Behavior by Elementary Science Teacher Trainees," John J. Koran, Jr. University of Texas, Austin, Texas.
4. "The Effects of Selected Teaching Methods on Creative Thinking, Self-Evaluation, and Achievement of Students Enrolled in an Elementary Science Education Methods Course," Alan J. McCormack, Colorado State College, Greeley, Colorado.
5. "An Analysis of a Method for Improving Science Problem-Solving Ability Possessed by Prospective Elementary Teachers," Marshall E. Parks, Indiana State University, Terre Haute, Indiana.
6. "Instruction on Questioning," Louis C. Konetski, Morgan State College, Baltimore, Maryland.

ROLE PLAYING AS A TECHNIQUE FOR DEVELOPING A SCIENTIFIC ATTITUDE IN ELEMENTARY TEACHER TRAINEES

Earl F. Hughes
Nova University
Fort Lauderdale, Florida

The purpose of the study was to determine the effectiveness of three types or degrees of attitude change techniques in changing the attitude of prospective elementary school teachers toward science. The desired attitude is that science is not just an accumulation of factual knowledge, but a way of thought or logical sequence of problem solving processes. This study utilizes the results and techniques of the attitude change studies in the psychological literature in an attempt to systematically approach the problem of science attitude by the use of a controlled sensitive experimental design.

A sample of 219 prospective elementary school teachers were administered a pretest measuring selected items of their attitude toward science. The subjects were assigned to one of four treatment groups which were stratified according to pretest attitude scores to insure that the three treatment groups and the control group did not differ in their original attitude toward science. A persuasive communication was administered to the three treatment groups three and one-half weeks after the pretest. The control group received an innocuous communication and the posttest, one treatment group received the persuasive communication and the posttest, the other two treatment groups received the persuasive communication. Of the latter two groups, one role played a proponent of the desired scientific attitude while the other observed the role playing. The hypotheses are being tested by the use of a canonical correlation and a multivariate analysis of variance technique to enable the use of correlated measures and unequal cell size in the statistical design. The data analysis is not complete so no statement of results or conclusions can legitimately be made.

The new elementary science curricula, with emphasis on process, discovery, inquiry, and creativity has no role for a teacher who views science only as a body of factual knowledge. Since the elementary teacher candidates have completed their required formal science courses, the elementary teacher science training courses must assume the responsibility for developing a more scientific attitude in these prospective teachers. This study investigates the technique of directly confronting prospective teachers with a persuasive communication that describes science as a way of thought, a technique that could be used in teacher training curricula.

ATTITUDES AND ATTITUDE CHANGE: ITS INFLUENCE UPON TEACHING BEHAVIOR

Helen H. James
University of Colorado
Boulder, Colorado

This study investigated relationships of attitudes toward aspects of science teaching, and performance in the classroom. Student-teachers were considered appropriate subjects since their attitudes and performances as teachers are probably more flexible, i.e., rapidly developing, than experienced teachers. Various questions probed included:

1. Do these attitudes of student-teachers change with involvement in classroom teaching experience?

2. Do these attitudes tend to become more compatible with those held by the cooperating-teacher?

3. To what degree do attitudes about science teaching concepts correlate with actual teaching behaviors?

Certain attitudes of secondary science student-teachers and each of their cooperating-teachers were ascertained by semantic differential technique before classroom teaching assignments began. Attitude information from student-teachers was again collected at the end of the semester.

To answer question (1), a multivariate design with "student-teacher" nested in "treatment group" was analyzed for difference between pre- and post-semantic differential scores.

The same experimental design was utilized to ascertain differences in attitudes between the student-teacher and his respective cooperating-teacher, before and after the student-teaching experience, i.e., question (2).

These students were concurrently involved in another aspect of this study concerning differential effects of university supervision in developing an inductive-indirect teaching strategy as follows:

(Control) Treatment Group (1) received traditional visitation and conference.

(Experimental) Treatment Group (2) received treatment (1) supplemented by filmed teaching models.

(Experimental) Treatment Group (3) received treatment (1) supplemented by self-evaluation of their classroom teaching via videotape recordings (VTR).

It was found through analysis of a videotaped final classroom teaching session for every student-teacher, that VTR did significantly facilitate development of the desired teaching behavior. However, a third approach to ascertaining development of an inductive-indirect approach to science teaching by these student-teachers, was <u>pupil</u> reported classroom activities. A modification of the Biology Classroom Activities Checklist (BCAC)[1], completed by randomly selected pupils in each student-teacher's classroom, provided information about typical classroom activity. Analysis of variance and Dunnett's multiple comparison method showed a significant, but opposite trend, i.e., in the direction of less inductive-indirect teaching by the experimental groups.

The question remained, whether attitudes of these student-teachers correlated with their "videotaped" behavior (a criterion more suited for maximum ability measurement), or whether they might have been "trained" for that performance while holding attitudes opposing such strategies. If this were true, the ability would likely not be retained and the supervisory accomplishment would be spurious. Pearson "r" correlations were calculated between the continuous variables, performance rating and semantic differential scores on the evaluation dimension for each science teaching concept. Thus, the attitude information for the student-teachers as well as their cooperating-teachers furnished explanations for this seeming paradox.

[1] Kochendorfer, Leonard, and Addison Lee. in <u>Research and Curriculum Development in Science Education</u>. Addison Lee (ed.), University of Texas Press, Austin, Texas, 1967, chaps. 8, 9, 10.

A COMPARISON OF THE EFFECTS OF OBSERVATIONAL LEARNING AND SELF-RATING ON THE ACQUISITION AND RETENTION OF A QUESTIONING BEHAVIOR BY ELEMENTARY SCIENCE TEACHER TRAINEES

John J. Koran, Jr.
University of Texas
Austin, Texas

The purpose of this study was to compare two modes of teacher training. The first, observational learning using live or videotape models has considerable research to recommend it. Its limitations are that the arrangement of conditions for this type of training is frequently difficult or impossible, and the cost high. An alternative, self-rating combines elements of modeling theory and operant conditioning, can take place in a science methods classroom, and is inexpensive. But before advocating one or the other method, it is necessary to examine their relative effect on the acquisition and retention of a criterion behavior.

Twenty-one preservice elementary teachers were randomly assigned to two treatment groups: a film-mediated modeling group and a self-rating group. Ss took a pretest on which they were asked to generate as many observation-classification questions as they could, using a given set of AAAS science materials. Subsequently, the film-mediated modeling group viewed a model of the questions to be generated while the self-rating group rated their pretest performance using a rater protocol as a guide. The independent variables here were observation of a film-mediated model of the behavior to be acquired, or rating a previous performance of a lesson taught. The dependent variable was the generation of observation-classification questions in writing. Each S was exposed to the training twice and to the performance measure before and after training and two weeks after the final training session. Time of exposure to training methods and criterion tests were equated. Three raters rated the behaviors generated by Ss with an interrater reliability of .97.

A two-way analysis of variance over three trials and two treatments in each trial showed that both training methods produced significant acquisition of the criterion skill over the training period. There were significant changes from trial 1 to trial 3 scores for subjects within groups ($p = < .05$). Furthermore, the retention test indicated that the self-rating group dropped in performance significantly after two weeks ($p = < .05$) whereas the film-mediated modeling group retained its level of performance.

It might be concluded that in cases where cost is a consideration, facilities limiting, and the task to be acquired is a relatively simple verbal behavior, self-rating training procedures in a science methods course are a practical and effective alternative to film-mediated modeling procedures. If, however, participants will not have a chance

to practice the acquired skills after training and be reinforced for their behaviors, modeling procedures appear to produce a greater retention of the acquired skills.

This study is part of a continuing line of research attempting to identify effective task and method variables in the instruction of science teachers. It is leading toward a model of science teacher education which considers aptitude x task x method variables.

THE EFFECTS OF SELECTED TEACHING METHODS ON CREATIVE THINKING, SELF-EVALUATION, AND ACHIEVEMENT OF STUDENTS ENROLLED IN AN ELEMENTARY SCIENCE EDUCATION METHODS COURSE

Alan J. McCormack
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Greeley, Colorado

This investigation has explored the effects of a modified elementary science education methods course on students' creative thinking, self-evaluation and achievement. Thirty juniors and seniors enrolled in Science Education 270 at Colorado State College for the Winter Quarter, 1969, comprised the experimental group for the study. Thirty-nine students enrolled in another section of the course were involved as a control group.

Lecture-discussion meetings were essentially the same for both groups. Laboratory sessions and related written assignments, however, varied. Control group laboratory sessions were organized around the standard course laboratory manual and related researcher-constructed Laboratory Supplements. Experimental group laboratory sessions were concerned with the same science topics, but certain creativity-training activities were also included. These were: (a) brainstorming; (b) inquiry development sessions; (c) morphological analysis of problems; and, (d) researcher-developed Invitations to Creative Thinking written exercises.

Pretest and posttest scores of fluency, flexibility, and originality of idea production were gathered for both groups through administration of the Torrance Tests of Creative Thinking (TTCT). Pretest and posttest achievement scores were determined through administration of the Science Education Achievement Test (SEAT), modified by the researcher from a test developed by Tillery Analysis of covariance was used to determine whether significant differences in fluency, flexibility, originality, and achievement occurred from pretest to posttest between the groups.

Two researcher-constructed instruments were administered at the conclusion of the course: The Self-Evaluation Inventory (SEI), providing data regarding students' ratings of their achievement of the forty-seven cognitive and eleven affective behavioral objectives specified for the course; and, the Course Evaluation Instrument (CEI), providing data on students' ratings of various portions of the course. A t test was used to determine any differences between group ratings of each of the SEI and CEI items.

The Pearson product-moment statistic was used to determine any correlation between the TTCT and SEAT posttest scores.

The experimental group was found superior to the control group in gains in fluency, flexibility, and originality TTCT scores at a highly significant level. No difference was found between groups in SEAT scores. The SEI data indicated essentially no differences between groups in self-ratings of achievement of <u>cognitive</u> course objectives, but the experimental group was significantly higher in ratings of <u>affective</u> objectives. In CEI ratings of twelve components of the methods course, no differences were found for ten of the items, while lecture-discussion sessions were rated significantly higher by experimental subjects, and the test-construction assignment was rated significantly higher by control subjects. A significant negative correlation was found between TTCT and SEAT posttest scores.

The findings of this study substantiate previous investigations indicating creativity can be improved. Entire courses in creativity-training, however, seem unnecessary. It appears creativity-training may be included as a portion of an existing elementary methods course and effect gratifying creativity improvement with no loss in subject-matter achievement. Coupled with this, the significant affective gains found associated with the inclusion of creativity-training in a modified methods course suggests methods courses could be improved by including creativity-training as a regular course of action. Some interaction may be operative between students' improved creativity and affective gains.

The significant negative correlation between creativity and achievement test scores suggests the highly creative methods course student may be discriminated against by standard subject-matter evaluation instrument orientation. Probably evaluation instruments should involve higher levels of thought, including creativity.

As a corollary to this investigation, specificatic . of cognitive and affective behavioral objectives, and the application of these in student self-evaluation has been a promising technique.

AN ANALYSIS OF A METHOD FOR IMPROVING SCIENCE PROBLEM-SOLVING ABILITY POSSESSED BY PROSPECTIVE ELEMENTARY TEACHERS

Marshall E. Parks
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Terre Haute, Indiana

This study was designed to determine if the critical analysis of science research papers improved the science problem-solving ability of the prospective elementary teacher. Further, an effort was made to determine: (1) the relationship between the student's problem-solving ability and his reading ability and (2) the joint effects of his reading ability and the instructional methodology on his problem-solving ability. A secondary goal of this study was to determine if relationships exist between the ability to solve problems in the laboratory and the student's ability to think critically, to recognize problems and to select modes of attack.

The investigation was limited to six laboratory sections of a science methods course for prospective elementary teachers at a midwestern state university. Three laboratory sections containing eighty-five students were randomly assigned to the control group, and three laboratory sections containing eighty-three students were similarly assigned to the experimental group.

Both the experimental group and the control group followed an inquiry oriented plan for laboratory instruction. Additionally, in the experimental sections, five research papers drawn from the history of science were critically analyzed. Copies of each research paper and the accompanying guide questions were distributed to the students. Subsequent class discussion was based on student responses to the guide questions. Evaluation involved the Nelson-Denny Reading Test, the Watson-Glaser Critical Thinking Appraisal, the Andersen Problem Recognition and Attack Skills Test and the investigator's laboratory performance test. These instruments were administered to all the experimental and control laboratory sections.

Analysis of variance was used to compute the significance of the difference between: (1) the experimental group and the control group and (2) the high reading ability group and the low reading ability group. In addition, this same statistical procedure was used to determine the interactive effects of the two variables, instructional methodology and reading ability, on problem-solving ability. The Pearson-r was used to calculate the correlation coefficient between the student's scores on the investigator's laboratory performance test and: (1) the scores on the Watson-Glaser Critical Thinking Appraisal and (2) the scores on the Andersen Problem Recognition and Attack Skills Test. The F ratio and the r ratio were compared to appropriate values in published tables at the .05 level of significance.

Within the limits and conditions of the study, the following results were obtained: (1) the students who critically analyzed the science research papers and the students who did not participate in this instruction showed no statistically significant difference in their problem-solving ability; (2) reading ability was not significantly related to the student's problem-solving ability at the end of the experimental treatment; (3) the joint effects of the student's reading ability and the methodology did not significantly influence his problem-solving ability; (4) there was a significant correlation between the student's ability to solve problems in the laboratory and his ability to recognize problems and to select modes of attack.

Although the statistical analyses of the data did not indicate that the critical analysis of science research papers improved the prospective elementary teacher's problem-solving ability, it seems possible that the procedure may have developed aspects of the problem-solving ability not measured by the instruments used in the study.

INSTRUCTION ON QUESTIONING

Louis C. Konetski
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Baltimore, Maryland

This investigation included studying the effects of two instructional strategies on three aspects of preservice science teacher behavior: (1) the number of divergent and evaluative questions asked; (2) the proportion of divergent and evaluative questions asked; and (3) the total number of questions asked. Both strategies included the same programmed instructional booklet; however, the instruction that followed the reading of the program differed among strategies.

A pretest was used to measure the entry behavior of preservice science teachers in four experimental groups. Following instruction, two posttests were made, each following one phase of instruction. The first phase included reading the instructional program, a handout describing the categories of questions, and either categorizing or designing questions. The second phase of instruction included a conference during which each preservice science teacher discussed his questioning behavior with the instructor. A fifth group (control) did not receive formal instruction on questioning, but did meet in conference with the instructor and received the handout describing the categories of questions used during this study. The investigator categorized questions from audiotape recordings made of 15-minute science lessons presented by the preservice science teachers. For purposes of data analysis, questions were categorized into either of two categories: (1) cognitive-memory and convergent; or (2) divergent and evaluative.

Analysis of variance and t test were the experimental designs used to test the significance of the variables studied. Instructors and proportion of divergent and evaluative questions asked during the pretest were used as covariables.

1. Instruction in classifying questions asked and instruction in designing questions significantly and positively affected both the number and proportion of divergent and evaluative questions asked.

2. Instruction in the use of divergent and evaluative questions significantly and negatively affected the total number of questions asked.

3. Conferences between the instructor and the preservice science teacher were more effective in affecting the divergent and evaluative questions asked when used in conjunction with the formal instruction presented during this investigation.

Divergent and evaluative questions focus attention on something more than regurgitation of factual information and produce divergent and evaluative thought in students. The implication that appears to be suggested from this research is that instructors can use either instructional strategy to increase the use of divergent and evaluative questions asked by preservice science teachers.

Session VIb - Children's Learning in Elementary School Science

Chairwoman: Rose Lammel, Wayne State University, Detroit, Michigan.

1. "Differences in Science Concepts Held by Children from Three Social-Economic Levels," Carol Klein, College of St. Catherine, St. Paul, Minnesota.

2. "The Image of the Scientist Among Elementary and Junior High School Students," Donald J. Schmidt, Fitchburg State College, Fitchburg, Massachusetts.

3. "Pictures of Scientists as Drawn by Children and Their Concept of Science," Kenneth W. Uhlhorn, Indiana State University, Terre Haute, Indiana.

4. "A Comparison of Categorizing Ability in High and Low Socio-economic Status Kindergarteners," Roger Johnson, Jr., University of Minnesota, Minneapolis, Minnesota.

5. "Science Classificatory Dimensions and Rules Used by Children," Leroy B. Weinbrenner, Trinity College, Deerfield, Illinois.

6. "A Comparison of Individualized and Group Instruction in Science: Effects on Third Grade Pupils," James Joseph Gallagher, Educational Research Council of America, Cleveland, Ohio.

DIFFERENCES IN SCIENCE CONCEPTS

HELD BY CHILDREN FROM THREE SOCIAL-ECONOMIC LEVELS

Carol Klein
College of St. Catherine
St. Paul, Minnesota

The purpose of this study was to determine if children from three social-economic groups differed in their understanding of selected science concepts and in the methods they would suggest to find answers to questions associated with the concepts.

Fifteen St. Paul, Minnesota elementary schools selected for the study were classified as serving high, middle, or low social-economic groups on the basis of information obtained from the city offices and the administration of the metropolitan school district participating in the study. Only schools that served a single social-economic group and that had no racial minority groups were included.

Science questions based on concepts selected from the system's basic text were tested in another suburban school district (comprised of children from the middle and lower social-economic groups) to determine their clarity and discriminating power. In addition to the fifteen questions finally selected for the test, the students were asked to suggest a way of finding out answers to each question whether or not they knew the answer.

In the May, 1968, pilot study, the test was administered individually by the researcher to sixty third grade children; their responses to the questions were tape recorded. Later, forty of these children took the test in written form. The questions were read aloud to minimize the possible consequences of different reading abilities. The means and standard deviations for the written and taped test scores were very similar and correlated .87 to .90. The test-retest reliability was, therefore, at these values. These results were believed to justify using a written test for the main study. In the fall of 1968, the written test was administered by the teachers in the same manner as the pilot study written form, providing data from 310 fourth grade students in fifteen classes in nine schools.

Questions and Results

Question	Tested by	Results
1. Is there a significant difference between the mean I.Q.'s of the three social-economic groups?	One-way analysis of variance Newman-Keuls Test	Significant difference at .01 level between each group. $\bar{X}$ = High 116.13, Middle 107.41, Low 99.72.

Question	Tested by	Results
2. Is there a significant difference between the mean scores on the test of scientific understanding when only raw scores are considered?	One-way analysis of variance Newman-Keuls Test	Significant difference at .01 level between each group. $\bar{X}$ = High 7.04, Middle 6.14, Low 2.71.
3. Is there a significant difference between the mean scores on the test of scientific understanding when the raw scores are adjusted for I.Q. differences?	Co-variance analysis Newman-Keuls Test	Significant difference at .01 level between low and high, 3.03-6.29; low and middle, 3.03-6.05.
4. Are there difference in the kinds of answers suggested by the three groups to the questions "How could you find out?"	Differences by percent	Major differences in Experiment-Observation. Selected least by low group. Low often suggested no answers.
5. Are there differences in the number of correct responses given by the three groups to individual test items?	Chi-square analysis	Significant at .05 level for 13 of 15 items. Low had least correct on each of the fifteen.

The children from the three social-economic groups differed in their mean level of understanding of the science concepts and in the methods they suggested to seek answers to these questions. When the mean score of each group was adjusted for I.Q. differences, the low social-economic group scored significantly lower than the other two groups.

If differences in levels of understanding science are associated with social-economic factors, as this study would seem to indicate, using the same text and materials for all schools may not be an effective teaching method. If science education is to be concerned with both the processes and products of science, a curriculum planned for children in the lower social-economic group may need to include more opportunities for experiment and observation.

The close agreement between the interview test and the written test read to the students to minimize reading problems suggests that the written test may be used in other research where large groups of children are to be tested.

THE IMAGE OF THE SCIENTIST AMONG ELEMENTARY AND JUNIOR HIGH STUDENTS

Donald J. Schmidt
Fitchburg State College
Fitchburg, Massachusetts

In 1957, Mead and Metreaux reported on the image of science and of the scientist among high school students. This report and several that have been given since that time have indicated that the "image" is something other than might be desired by those of us interested in science and science education.

In studying the understanding of science, this author and many others have made use of testing instruments such as the Test On Understanding Science. The very nature of this instrument limits the study to students with maturity and a rather well developed vocabulary. Other attempts have been made by this author and others to study the "image" from written paragraphs but again the limiting factors are the students themselves, their ability to express their image on paper in paragraph form. Thus, most of the study of the understanding of science deals with students from grade 7 through college.

Despite the limitations of the previous studies, there is some evidence that a great deal of the attitude toward and the image of science is developed during the elementary school years. The problem then is simply, how can the image of the scientist among the younger students be studied? Of course, the goal of the study is to find out what the image of the scientist really is.

Preliminary attempts to solve the problem involved asking the elementary and junior high students to say what characters they have seen on television seem to look and act like scientists. Another approach was to ask them to say what person in their personal contact life looks and acts like a scientist.

Based upon the data collected during the preliminary attempts described above, an instrument was devised to be used by the elementary and junior high student to visually create his mental image of the scientist. With the aid of an artist and by the use of many photographs, a series of transparencies were developed that were so constructed as to allow the student to create the type of person he wanted to represent his image of the scientist. For example, one transparency would be the head, another a body, another a specific type of laboratory surrounding, etc. By simply superimposing the various transparencies the student builds the picture of the "scientist".

The results of the questioning about characters that act and look most like scientists are quite shocking. Over 90% of the persons indicated could in no way be considered to be scientists, or for that matter be considered to be involved in any activity remotely related to science. The results of the "image creation" portion of this study were equally disturbing. Most young persons think of the scientist as being

at least middle aged, wearing a white coat and being a bit odd. This study indicates that it is possible to find out something about the image of the scientist among elementary students who do not have the ability to respond to more sophisticated paper and pencil examinations. Personal interview techniques utilizing the visual representation technique described above proved to be most useful.

PICTURES OF SCIENTISTS AS DRAWN BY CHILDREN AND THEIR CONCEPT OF SCIENCE

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When science educators attempt to discover the concept elementary school age children have of science, they are faced with many problems. The major problem seems to be the inability of primary and some intermediate children to express themselves verbally.

This study uses the drawings of scientists made by approximately 2800 elementary children to investigate their concept of science and scientists. The major assumptions being that what the person in the picture is doing is science and that background experiences the children have had that relate to science and scientists will be identifiable in the pictures.

Each picture was analyzed to see which of thirty-five different characteristics were included. Generally the characteristics could be grouped into the following categories:

1) the appearance of the scientists;

2) the laboratory and the materials found there; and

3) the areas of science which are represented.

The grade, school, and sex of the child who drew the picture was also included with the analysis.

The percent of the total number of children at any grade level who included in their drawing the same characteristic comprised the statistic used as a basis for generalizing at that grade level. If 50% or more of the children at a given grade included a characteristic in their picture it was assumed that this could be considered typical for their grade. In addition, the ten most frequently drawn characteristics were also noted for each grade.

A chi square test was used to analyze the differences between the numbers of children at each grade who included a specific characteristic of a scientist. This test was also used to investigate the difference in the number of boys and girls at the same grade level who included the same characteristic on their drawings.

If a concept can be defined as an understanding which is based on past experiences, then one can assume that the children's pictures represent their science-scientist understanding based on the experiences they have had. If this is the case, what are the experiences which have given the children the concepts they have illustrated on their drawing and when in their educational process have these experiences played a significant enough role to influence their drawings?

Generally, the results of this investigation indicate that the stereotyped scientist of the television cartoon and comic book predominate the child's concept of science and scientist from grades 2 through 6. Also, at these grade levels, that he is a chemist and works in a laboratory filled with glassware and chemicals. The students in the primary grades indicate only that the scientist is a person and, more specifically, a man. This study has also implied that the concepts children have of science and scientists are cumulative becoming more complete as the children progress through the grades.

It should be pointed out that there has been no attempt to analyze the artistic talent or ability illustrated by the children's drawings. No attempt has been made to obtain any of the children's explanations of what they have drawn.

The generalizations made in this paper are based on the drawings of students of in-service teachers who were involved in extension classes taught by the author at several extension centers of Indiana State University. No attempt was made to control the instructions given to the students other than that they were to make drawings of scientists or was any time limit given for making the drawings.

The technique used in this study has many possibilities in investigating children's concept of science and scientists. It is a non-verbal technique which can be used successfully in the primary grades as well as in the intermediate grades. The potential of this mode of investigation is one which science educators should not overlook.

A COMPARISON OF CATEGORIZING ABILITY IN HIGH AND LOW SOCIOECONOMIC STATUS KINDERGARTENERS

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Two studies were conducted to investigate (1) the basic mental operations of young children which allows them to organize the sensations received from their environment and (2) the differences and similarities of children from differing socioeconomic status backgrounds in their ability to perform these organizations. The studies were conducted in the spring of 1967 (study A) and spring of 1968 (study B). Since study B was an extension and replication of study A, the designs were basically identical and they will be described together with any differences pointed out.

The samples were drawn from the Oakland School District (Oakland, California) on the basis of socioeconomic status data collected by the district. The criteria for SES involved family income and breadwinner's occupation, (also collected were the mobility of student populations, average unexcused absences, and the racial composition of the schools). The samples were randomly selected for each study from eight kindergartens with four different teachers (study A: N=40; study B: N=60).

The design used was the Posttest Only Design with the independent variable being socioeconomic status. Comparisons were made in connection with SES, Sex, the nature of the attribute, the number of attributes present, the strategies used, and the horizontal development of categorizing. The dependent variable of categorizing ability was measured with four tests modified from the Lawrence Lowery Apperception Tests (Lowery in press for spring 1970, AERJ) and a follow-up interview using concrete materials (attribute blocks). The testing required the student to recognize and compare attributes for similarities and to categorize them into groups. They were administered to groups of four or five students with one out of every five students then being interviewed on the basis of his previous responses. The students interviewed were systematically selected to represent high, medium, and low scorers. The data were analyzed statistically using the analysis of variance with repeated measures, and analyzed descriptively using observations and audiotapes.

The High SES kindergarteners demonstrated more ability to consistently categorize on attribute resemblance than the Low SES sample (X=.05). Although categorizing is a cognitive process and extreme care was taken in the research, affective variables (self-image, motivation, etc.) undoubtedly had some effects on the scores. The cognitive similarities were numerous with both groups showing very similar strategies, trends in the test scores patterns, preference of attributes and types of errors. These results indicated a similar cognitive development in categorizing with the possibility of a slower

pace in the Low SES sample. There were no differences evident between boys and girls as total groups or within SES groups.

In comparing the students ability with different attributes, both SES groups demonstrated preference for the attribute shape over size and pattern. Any differences in ability between size and pattern were not significant (x=.01). Comparisons of ability to deal with single, double, and triple attribute problems were obscured by the attribute preference data.

All of the kindergarteners were able to categorize at some level using almost exclusively a "perceptual focusing" strategy involving a seemingly random choice of a focus picture and a one to one search for identical pictures. The task was extremely simplified when the focusing picture was supplied indicating the importance of the initial focusing part of the strategy and being able to shift focus if not successful. The kindergarteners also displayed ability in discrimination, but some confusion concerning equivalence which is understandable as the child has the natural sensory equipment to differentiate phenomena, but equivalence is an intellectual invention of man which the child is developing.

Since the mastery of categorizing is both necessary and natural and begins with birth not with kindergarten, it would seem profitable to promote programs which make use of less dominant attributes than shape or color, emphasize multiple ways of grouping and which grouping is most efficient, and perhaps make the process of categorizing a more conscious one.

SCIENCE CLASSIFICATORY DIMENSIONS
AND RULES USED BY CHILDREN

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Deerfield, Illinois

This study was designed to identify the classificatory dimensions and rules used by children when grouping science-related objects; to compare these classificatory dimensions and rules with the classificatory dimensions and rules used in science; to determine the relationships between the types of classificatory dimensions and rules used by children, and their sex, ability level, and neighborhood type; and to identify any trends existing over grade level in the classificatory rule usage by children.

One rural school, one suburban school, and one inner-core urban school were selected for this study. Within each school two boys, one each of high and low ability, and two girls, one each of high and low ability, were selected at each grade level, one to eight.

The data were gathered in individual interviews, each child being asked to group sets of science-related objects into subsets. The data were comprised of observations of the groupings formed by the children and of responses by the children to the investigator's queries concerning the nature of the dimensions and rules used for the establishment of the subsets.

The classificatory behavior of the children in this study is described as follows:

1. About three-fourths of the subsets formed by the children were based upon dimensions which are also used in designing science classificatory concepts.

2. About half of the subsets formed by the children were based upon a Gross dimension such as color, shape, size, or texture. The other half of the subsets were formed using dimensions classified as Inferred, Fine, Phenomenalistic, Environmental, Compositional, and Appellative. The children formed only small numbers of subsets using dimensions classified as Behaviorial, Utilitarian, Derived, and Theoretical.

3. Every child established subsets using the Gross dimension and more than half of the children established subsets using the Environmental, Phenomenalistic, Fine, Inferred, Compositional, and Appellative dimensions.

4. The children used the one attribute rule in forming 95 percent of their subsets and the conjunction of dimensions rule in forming five percent of their subsets.

5. Two-thirds of the children's acceptable groupings were based on one dimension.

6. Comparisons among the sex subpopulations, the ability level subpopulations, and the neighborhood type subpopulations indicate that, with some exceptions, the boys and girls exhibited similar grouping behaviors; the high and low ability children exhibited similar grouping behaviors; and the rural, urban, and suburban children exhibited similar grouping behaviors.

7. There were irregular increases with grade level in the number of subsets formed, in the use of the Appellative and Inferred dimensions, and in the number of one dimension and dichotomous groupings formed by the children. Above grade four the usage of different acceptable dimensions or the usage of abstract dimensions did not increase.

8. Comparison of the sex, ability level, and neighborhood type subpopulations at each grade level again revealed that the subpopulations of children exhibited similar grouping behavioral trends.

A COMPARISON OF INDIVIDUALIZED AND GROUP INSTRUCTION IN SCIENCE: EFFECTS ON THIRD GRADE PUPILS

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Cleveland, Ohio

This study was designed to examine differences in pupil behavior and achievement resulting from an individualized instructional approach and the more traditional, teacher-directed, group instruction.

Four groups of fifteen pupils were randomly selected from public school third graders in a middle-class suburban community. Pupils from one of the groups were given, individually, a two lesson instructional sequence using the audio-tutorial mode. Pupils in a second group were given the same two lesson sequence in the familiar, teacher-directed, group mode. Pupils in the third group were given the first lesson of the sequence individually, in the audio-tutorial mode and the second lesson as a teacher-directed group. The fourth group served as a control and received no instruction.

The lessons were adapted from <u>Interaction</u>, a unit prepared for primary school children by the Science Curriculum Improvement Study. The lessons followed the instructional plan outlined by the unit's writers; that is the first lesson provided an opportunity for "exploration," and the second focused on "invention" and "discovery." The individualized lessons and those in the group mode paralleled each other as closely as possible.

Three types of data were collected:

1. <u>Achievement Data</u> - a variety of posttest data on pupils' understanding of, and ability to apply the concept of interaction.

2. <u>Process Data</u> - information about pupil behavior during the instructional sequence. Included are data on specific tasks children were required to perform and a videotape record of all overt pupil behavior during the instructional sequence.

3. <u>Pupil Background Data</u> - scores on standardized tests which are part of each child's permanent school records.

Analysis of the process data showed marked differences in the nature of the experience which children undergo in the two instructional modes. In the individualized mode, pupils attended chiefly to the

concrete materials that embodied the phenomenon which was being studied; whereas, in the group setting, the child's attention was shared among the materials, the teacher, and other pupils. The individualized setting, provided in this study, seemingly allowed pupils freedom from distraction while examining materials, making observations, and reflecting on what was observed. By contrast, the group mode was characterized by greater inter-personal interaction. Achievement data showed tendencies which were compatible with pupils' experiential differences.

This study constitutes an early step in a needed examination of the effects of different instructional modes on learners. These preliminary data suggest that the choice of instructional mode may sharply alter the nature of the learning experience and consequently influence the instructional outcomes.

Session VIc - Symposium: The Educational Encounter: Toward a Theory of Teacher Education

Chairman: Howard L. Jones, University of Houston, Houston, Texas.

Speakers: E. Glenadine Gibb, University of Texas, Austin, Texas.

Glen McGlathery, University of Colorado, Boulder, Colorado.

Alan Steinbach, St. John's College

Chester Raun, Temple University, Philadelphia, Pennsylvania.

David Butts, University of Texas, Austin, Texas.

Discussants: J. M. Atkin, University of Illinois, Urbana, Illinois

Gene E. Hall, University of Texas, Austin, Texas.

GENERAL SESSION B

Presiding: Alan M. Voelker, University of Wisconsin, Madison, Wisconsin.
Speaker: R. Bruce Lindsay, Brown University, Providence, Rhode Island.
"A Unified Approach to Science Teaching"

The tremendous impact of science on society suggests that a more effective grasp of this important way of looking at human experience should be provided to the students passing through our educational system. The present need is made all the greater by a misunderstanding of the fundamental nature of science now prevalent in the general population. Science is all too commonly confused with technology, a related but essentially different discipline.

Science education is indeed currently making substantial progress through the development of new curricula in general science in elementary and secondary schools throughout the nation. However, there still exists the strong tendency to follow the general science courses with year courses in specific branches, i.e., physics, chemistry, and biology, in the last two years of high school. The same sort of program persists in large measure in introductory science courses in colleges and universities, even for those students who do not intend to embark on professional careers in science. This seems unfortunate, since in such specific subject matter courses the real significance of science may easily get lost amid the factual details of the separate branches. The fundamental unity of science is usually entirely overlooked, as well as its relations with other ways of looking at and attaching meaning to human experience, namely the humanities and the social studies.

It is the purpose of the present paper to suggest the introduction into advanced secondary school and elementary college programs of courses of study which will emphasize science as a method for the description, creation and understanding of all aspects of human experience. Such a course will necessarily involve a thorough examination of each category in the method, along with a wealth of illustrations from all branches of science. It will stress the nature of scientific theorizing, the historical development of scientific concepts, the behavior patterns of scientists, the unity of science, the relations of science with technology and the state and the influence of science on human thinking and activity, past and present.

Such courses will inevitably demand changes in the methods of training science teachers for the secondary schools, as well as some modification in the outlook of college teachers. They will also entail the design and preparation of new educational materials, including more appropriate written materials, audiovisual aids and equipment for simple but effective demonstrations and laboratory experiments.

Through such courses of study as are suggested here, it is hoped that our young people will ultimately gain a better understanding of the meaning of science and its role in our civilization.

Concurrent Sessions VII

Session VIIa - Instruction and Evaluation in Elementary School Science

Chairwoman: Katherine E. Hill, New York University, New York, New York.

1. "An Approach to Concept Assessment," Edward L. Smith, Southwest Regional Laboratory, Inglewood, California.
2. "Group Achievement Tests Developed for Two Basic Processes of AAAS Science-A Process Approach," Jean Beard, San Jose State College, San Jose, California.
3. "Development of Test Items Related to Selected Concepts within the Scheme the Particle Nature of Matter," Rodney L. Doran, State University of New York at Buffalo, Buffalo, New York, and Milton O. Pella, University of Wisconsin, Madison, Wisconsin.
4. "Development of the Science Curriculum Assessment System (SCAS): Part One, Introduction and Interview Protocols," Darrell G. Phillips, University of Iowa, Iowa City, Iowa, and Charles C. Matthews, Florida State University, Tallahassee, Florida.
5. "Development of the Science Curriculum Assessment System (SCAS): Part Two, Classroom Observational Systems and Conclusion," Charles C. Matthews, Florida State University, Tallahassee, Florida, and Darrell G. Phillips, University of Iowa, Iowa City, Iowa.

AN APPROACH TO CONCEPT ASSESSMENT

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Southwest Regional Laboratory
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To answer questions about the role and placement of abstract concepts in the elementary school science curriculum, techniques are needed for exploring or mapping out children's versions of them. The study reported here was an attempt to develop a comprehensive approach to concept assessment.

To guide the development, a notion of what was meant by concept was adopted. Using this notion of concept, a domain was defined for the concept of heat and a framework for generating and describing assessment tasks was developed. This framework mapped out the conceptual territory to be assessed by defining classes of situations within the domain of the concept and specified the kinds of operations the children would be required to perform for the assessment (describing, predicting, and accounting for). On the basis of responses obtained in preliminary interviews with first and fifth graders, a framework for classifying and describing children's responses was developed. This framework distinguishes between the following general types of response as well as content specific subclasses of each.

1. Precausal - Responses employing animism or artificialism.

2. Mechanistic - Responses employing an unobserved, nontheoretical process to account for a phenomenon.

3. Concrete - Responses referring to an observable object or substance as a causal agent.

4. Theoretical - Responses employing theoretical constructs.

A set of thirty-five tasks covering a limited portion of the domain of the concept of heat was prepared together with standard procedures for assigning the tasks in an interview situation. These tasks were then assigned to four groups of ten children in individual interviews. An independent sample design was used. Two groups consisted of first graders and the other two of fifth graders. One group at each grade level had received special instruction which had been expected to effect their concepts of heat.

Various techniques for describing the results were developed and illustrated using the data obtained. Among these were the proportion of correct predictions and a score reflecting the distribution of responses over the four types of response listed above. The fifth graders scored significantly higher on both of these measures than did the first graders. There were no significant differences between the two groups at each grade level on these measures.

Criteria for evaluating various aspects of a concept assessment program were developed. The paper reports these criteria and describes specific evaluation procedures for each. The application of this assessment approach to curriculum development and evaluation are also discussed.

GROUP ACHIEVEMENT TESTS DEVELOPED FOR TWO BASIC PROCESSES OF AAAS SCIENCE-A PROCESS APPROACH

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San Jose, California

The major purpose of the study was to determine whether science process achievement tests could be developed for administration to groups of primary grade pupils. Six Basic Science Process Tests (BSPT) were constructed as samples of the format proposed. Each BSPT was designed to assess one of the basic science processes taught in Parts A, B, and C of the 1967 edition of Science-A Process Approach (Sci-APA). The test items were projected 35mm color slides with a tape recording which asked questions and controlled slide advancement.

Pilot studies with 320 pupils in kindergarten, and first and second grades in Corvallis and Portland, Oregon during the spring of 1968, contributed to the development of general testing procedures and directions for training pupils to use BSPTs. Preliminary indications of item performance and time requirements were determined from administration of validated items to pupils just completing a year of Sci-APA study at minimum expected grade levels. The sample BSPTs were assembled and synchronized for automatic administrations to students who had studied the 1967 edition of Sci-APA.

Measuring and Classifying BSPTs were administered twice to 850 pupils in first, second and third grade classes in Park Falls, Phillips and Rhinelander, Wisconsin during September, 1968. More than 100 students took each BSPT at the minimum expected grade level and had experience in Sci-APA the previous year. More than 100 other students in the same grades who had no Sci-APA experience took the same BSPTs. The two administrations of each BSPT yielded test-retest score pairs which were correlated for each experience group to give reliability estimates for each BSPT.

The major purpose was to determine whether individual primary grade pupils could be assessed in class-size groups to determine their science process achievements. The administrations of the standardized synchronized BSPTs were accepted as reliable on the basis of test-retest correlations. Thus, it was concluded that successful educational measurement instruments can be constructed to assess science process achievement using this format.

A second question was to determine whether there was a difference in BSPT results between students who had and had not studied Sci-APA for a year. The groups with one year of Sci-APA experience had significantly higher mean scores on three of the six BSPTs than the groups without Sci-APA background. Both of the reliable BSPTs which assess process achievements taught in Part A of Sci-APA produced significantly higher means for Sci-APA pupils.

DEVELOPMENT OF TEST ITEMS RELATED TO SELECTED CONCEPTS WITHIN THE SCHEME THE PARTICLE NATURE OF MATTER

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Milton O. Pella
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Center for Cognitive Learning
University of Wisconsin
Madison, Wisconsin

The purpose of this study was to develop test items related to selected concepts from the scheme, the particle nature of matter, that are valid, reliable, and useable with pupils at grade levels two through six.

The test items were of the alternate response single concept type. Five items were developed for each concept and each involved a different but associated natural phenomenon. The concepts were selected by the University of Wisconsin Research and Development Center Science Project staff.

The test items were administered to two groups of students from each of five grade levels, two through six, in one elementary school. One class at each grade level received instruction related to the selected concepts by the regular classroom teacher. Teaching procedures and materials employed in the instructional sequence were developed by the Research and Development Center Science Project staff. The control classes did not receive the instruction. Each of the test items was administered to each class in both groups as a pretest and as a post-test.

Item validity was judged with respect to the following criteria: (1) the item is concerned with the selected concepts (Criterion #1), (2) the proportion of the experimental group choosing the accepted response to each item, when administered as part of a post-test, is greater than 0.50, the level attributable to random guessing (Criterion #2), (3) the proportion of the experimental group choosing the accepted response to each item when administered as part of a posttest is greater than when administered as part of a pretest (Criterion #3), (4) the proportion of the experimental group choosing the accepted response to each item, when administered as part of a post-test, is greater than when administered as part of a post-test to the control group (Criterion #4), and (5) the proportions of the experimental classes choosing the accepted response to each item, when administered as part of a post-test, will increase progressively with grade level (Criterion #5).

Since the degree of difficulty and discriminating power of test items influence their reliability, an item was judged reliable if the following criteria were satisfied when the item was administered as a post-test to the experimental group: (1) the item is of nonextreme difficulty,

$-2\sigma \leq X_{50} \leq +2\sigma$, (Criterion #6), and (2) the item is a strong positive discriminator, $\beta \geq +0.30$, (Criterion #7).

The useability of the items (Criterion #8) was judged on the following: (1) the item can be administered and scored easily, (2) test length within a normal elementary class period, and (3) the reading demands on the students are minimal.

Item response data for the several groups, grade level, and treatment effect (instruction or no instruction) were analyzed to determine the validity, reliability, and useability of the test items. Items that met six of the eight criteria were considered "acceptable" items. In some cases, the spurious performance of one or two classes was the reason for an item failing the criteria. In other cases, when most of the experimental classes experienced a pretest to post-test decrease, it is possible that the instructional sequence was inadequate.

Two items satisfied all eight of the criteria and 104 met six or more of the criteria. The criterion most frequently failed was #5, "grade effect," met by only two items. Each of the other criteria were satisfied by 100 or more of the 125 test items. The test items that failed three or more criteria were considered inadequate.

DEVELOPMENT OF THE SCIENCE CURRICULUM ASSESSMENT SYSTEM (SCAS)

PART ONE: INTRODUCTION AND INTERVIEW PROTOCOLS

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Florida State University
Tallahassee, Florida

Because we are becoming increasingly aware of the importance of science and early school experiences in science, tremendous effort and financial expenditure are going into curriculum reform in science at the elementary school level. Supported largely by the National Science Foundation, scientists and educators have cooperated during recent years in developing materials and programs for elementary school science teaching. The impact of materials and programs developed by the American Association for the Advancement of Science, Elementary Science Study, Science Curriculum Improvement Study, etc., has not been systematically assessed. Data are not available on the extent to which elementary school science teaching and learning have been altered by these and other recent federally-supported programs.

Although efforts have been made at evaluating the new elementary school science programs, there has been no uniform system available for monitoring changes associated with the implementation of science programs. It is especially unfortunate that we have not contrasted existing programs with new programs in terms of behaviors of children and teachers or in terms of the intellectual development of the children. It is equally unfortunate that we have not contrasted one new program with another.

Many science programs have been evaluated by various means during their development with little or no attention to changes in the classroom behaviors of teachers of the programs and with little attention to the day-to-day classroom behaviors of the children. Little or no program evaluation has been directed toward investigating changes in the child's intellectual development as measured by his interpretation of the physical environment; and this should be the ultimate criterion for determining the value of a science program.

Numerous researchers are applying the techniques of interaction analysis (developed by Flanders and others) to the study of changes in classroom behaviors of teachers and children and countless children are being studied (utilizing adaptations of Piaget's techniques) in an effort to identify logical operations associated with their interpretations of their environments. However, little or no work has been directed toward associating classroom behaviors with the child's interpretation of his environment.

SCAS is a system for monitoring changes (in children and their teachers) associated with the classroom implementation of a variety of science curricula. SCAS combines the interview techniques and theories of Jean Piaget with the techniques of classroom interaction analysis. SCAS provides a system for studying the intellectual development of children, classroom behaviors of children and their teachers, and various elements of the science curriculum.

This paper is intended to describe the overall purposes of SCAS, and to describe in more detail the development and application of "Piaget-type" individual interviews with children. The paper also describes means of training interviewers and the procedures used in the interpretation of data collected by interviewers. It reports and interprets data from over 250 children in grades K-6.

The form of the individual interview employed in SCAS is not identical to the clinical method employed by Piaget. Since SCAS is designed to sample the way in which a child interprets a particular part of his environment, the SCAS interview employs prescribed protocols and is therefore more restricted than the Piaget clinical interview. The twelve SCAS interview protocols are described in detail in the first trial edition (May, 1968) of the Handbook for the Application of the Science Curriculum Assessment System.

DEVELOPMENT OF THE SCIENCE CURRICULUM ASSESSMENT SYSTEM (SCAS)

PART TWO: CLASSROOM OBSERVATIONAL SYSTEMS AND CONCLUSION

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Darrell G. Phillips
University of Iowa
Iowa City, Iowa

Although SCAS may be applied to a science curriculum for a variety of reasons, its development has been primarily for the purpose of identifying relationships among classroom behaviors of the child, classroom behaviors of the teacher, and the child's interpretation of his environment. SCAS provides a means for monitoring changes (in children and their teachers) associated with the classroom implementation of a variety of science curricula.

Whether one is developing a curriculum or attempting to monitor implementation of a well-established curriculum, it is important to collect information from teachers and children in the natural environment of teaching and learning. It is inconceivable that any curriculum should be evaluated or that any curriculum should be developed in the absence of systematic and objective classroom data collection. Systematic collection of data in the classroom has been slow in coming. It is apparent that classroom data collection involving observation of teaching has a much longer history than data collection involving systematic observation of teaching.

This paper describes procedures whereby data from teachers and children may be collected in classrooms. The techniques of interaction analysis (including matrix analysis) are applied to the collection and analysis of these data. The categories applied to the classroom behaviors of teachers and students have been developed specifically for the Science Curriculum Assessment System and constitute the "SCAS Classroom Interaction Categories." The techniques for application of these categories have also been developed specifically for SCAS and constitute the "SCAS Observational Techniques."

SCAS Classroom Interaction Categories place classroom behaviors into two major groups: teacher behaviors and student behaviors. Student behaviors are further categorized into: (1) those behaviors which are related to the lesson and (2) those behaviors which are not related to the lesson. Each of these two categories is subdivided into ten specific student behavior categories.

Teacher behaviors are divided into two major groups: (1) teacher interactions with less than seven children, and (2) teacher interaction with more than six children. These teacher behaviors are each divided into ten categories. One of the ten categories in each subgroup of teacher behaviors

and of student behaviors is reserved for non-codable behaviors. Therefore, by a relatively simple coding system it is possible to code 20 different classroom behaviors of teachers.

A classroom observer who applies SCAS Observational Techniques will at any given time be focusing his attention on one individual in the classroom. Three classroom observers form a team in which one member observes the teacher, and each of the remaining two team members observes six children. Detailed descriptions of SCAS Classroom Interaction Categories and Observational Techniques are found in the Handbook for the Application of the Science Curriculum Assessment System (First Trial Edition, May, 1968).

The Science Curriculum Assessment System has been applied in fifteen classrooms in Atlanta, Georgia, and in twelve classrooms in Tallahassee, Florida. Specific questions related to classroom behaviors of teachers and children can be answered quantitatively. This is made possible by matrix analysis and computation of specific behavior "scores."

From interview data each child is described in terms of his response to specific questions in uniformly administered tests. The extent to which a child has used "logical operation" when confronted with various aspects of his environment can be inferred.

Relationships among variables have been investigated by suitable statistical methods (i.e., analysis of variance, regression techniques, scalograms, etc.). Particular emphasis has been placed on identifying changes in the child's perception of his environment, the child's classroom behaviors, and the teacher's classroom behaviors.

This paper reports and interprets classroom behavioral data from 250 children and 27 teachers in grades K-6.

Session VIIb - Science Instruction in the Junior High School

Chairman: Abraham S. Fischler, Nova University, Fort Lauderdale, Florida.

1. "Determining the Level of Inquiry in Teachers' Questions," George T. Ladd, Boston College, Chestnut Hill, Massachusetts.

2. "A Comparison of Group and Individualized Instructional Techniques in Seventh Grade Science," Robert James, Kansas State University, Manhattan, Kansas.

3. "Logical Thinking in Seventh, Eighth, and Ninth Grade Students." Robert E. Lepper, California State College at Fullerton, Fullerton, California, and Darrell G. Phillips, University of Iowa, Iowa City, Iowa.

DETERMINING THE LEVEL OF INQUIRY IN TEACHERS' QUESTIONS

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Boston College
Chestnut Hill, Massachusetts

The main null hypotheses are

(1) There will be no significant agreement between the judges as to the level of inquiry required by each category of the Smith and Meux (1960) question classification scheme.

(2) There will be no significant agreement between the judges as to the appropriateness of the proposed definition of the word inquiry as it is commonly used in the context of a classroom discussion.

(3) There will be no significant effect attributable to the inquiry level of teacher questioning on group achievement on either low or high inquiry post-test questions.

A judge's rating scale was sent to sixteen science educators throughout the United States. The scale was used to (a) classify each category of the classification scheme as the level of inquiry required, (b) assess the appropriateness of the proposed definition of the word inquiry. The results of the rating scale were used by seven experienced secondary science teachers in selecting twenty-five low and twenty-five high inquiry earth science questions for use on the post-test examination.

Audio tape recordings were made of three specific classroom discussions taking place in forty ninth grade earth science classes where an experimental curriculum was being evaluated. To determine the predominant inquiry level of a teacher's questioning behavior transcripts of each tape were prepared and analyzed by the investigator. This analysis was combined with the class mean I.Q. (as measured by the Differential Aptitude Test) and group achievement scores on the low and high portions of the post-test examination for statistical analysis.

The statistical techniques used to evaluate the experimental data included (a) proportions, (b) Scott's reliability coefficient, (c) analysis of covariance with one covariable (I.Q.), and (d) test for homogeneity of regression.

All null hypotheses were rejected with

(1) The judges showing significant agreement on the (a) level of inquiry required by each category of the classification

* Formerly at Indiana University. Bloomington, Indiana.

scheme (83.3 percent), (b) appropriateness of the proposed definition of the word inquiry (93.8 percent).

(2) There being a significant effect attributable to the level of teacher questioning on group achievement on both low and high inquiry questions (beyond the .001 level of confidence).

In recent years the practice of emphasizing only low level questions has been decried because they fail to elicit higher levels of thought and because they give students the impression that science is nothing but a conglomeration of facts. Considerable emphasis has been placed on searching for ways and means of developing teachers' ability to ask high level thought provoking questions, and to maintain this ability once developed. These efforts have not, however, been too successful. The questioning practices of today's teachers is not significantly different than the practices of the teachers studied in the early part of the century. A possible explanation for this failure is that the teachers are not aware of the level of cognition which their questioning can elicit in their student and its relationship to student achievement.

This research provides a refined instrument with which the classroom teacher can directly and accurately measure the level of inquiry of his questions. With this increased awareness the teacher can modify his questioning behavior and thereby change the students conception of science and his performance.

A COMPARISON OF GROUP AND INDIVIDUALIZED INSTRUCTIONAL TECHNIQUES IN SEVENTH GRADE SCIENCE

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The Intermediate Science Curriculum Study (ISCS) has developed a junior high school science program. An integral part of this program is a set of semiprogramed materials which eliminate group-instructional techniques and thereby make it possible to individualize the instruction. The purpose of this study is to compare outcomes between two classes where one was taught with methods similar to those suggested by ISCS and the other taught by group-instructional techniques.

The seventh grade science course, Matter, at University Schools, University of Iowa, has a rationale similar to that reported for ISCS. Materials prepared were based on the content outline for the Matter course. The two classes of about thirty students each were taught by the same teacher. The content was the same. Hypotheses were stated regarding five areas of student outcomes. These included: achievement of facts and concepts, development of critical thinking skills, understanding of the nature of science, subject preference, and retention of facts and concepts. Three levels of general aptitude were established. Half of each level was randomly assigned to each treatment. This facilitated the use of analysis of covariance within a treatment by levels design. Post-test scores were adjusted on the basis of pretest scores. Retention scores were adjusted on the basis of post-test scores.

The null hypotheses of no significant difference was used at the 0.05 level for achievement and retention of facts and concepts, development of critical thinking skills, subject preference, and understanding of the nature of science. In the understanding of the nature of science, the two treatments differed significantly on only one of five subtests. Though not statistically significant, the adjusted means for the individualized class consistently surpassed those for the group-instructed class in the scores on Read General Science Test; Seventh Grade Matter Final; Watson-Glaser Critical Thinking Appraisal, total score; Test on Understanding Science, total score; Prouse Subject Preference Test; and Silance Attitude Scale.

In a student opinionnaire 80% of the individualized class would elect individualized instruction next year, although nearly half of the lower level students preferred group instruction. About 50% of the individualized class described themselves as easily distracted during class as compared to 70% in the group-instructed class. A larger portion of the individualized class was inclined to think that the social interaction inherent in this class had helped them learn to get along better with their classmates. In making comparisons with other classes, the students in the individualized class were more prone to report that they had solved more

problems, taken more of the responsibility for their learning, and participated more in the class. It is particularly interesting that a number of better students in the individualized class thought they received less teacher-attention and felt less at ease compared to their classes.

In general, this study indicates that the use of these materials results in measured outcomes which do not differ significantly from those of group instruction. Materials of this type may constitute a basic course from which the teacher may digress in an effort to individualize instruction without a loss in measured learning outcomes. Perhaps this is the most significant conclusion suggested by this study.

LOGICAL THINKING IN SEVENTH, EIGHTH, AND NINTH GRADE STUDENTS

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Iowa City, Iowa

Five problems from The Growth of Logical Thinking by Inhelder and Piaget, were presented to sixty seventh, eighth, and ninth grade students at Fullerton, California and Iowa City, Iowa. Subjects were selected randomly from participating classrooms, and the data were collected by means of individual interviews with each subject.

The work of Jean Piaget has prompted the performance of numerous research studies. Most of these investigations have concentrated heavily upon various aspects of "conservation" tasks which examine the child's interpretation of certain invariant properties of objects. Since many conservation tasks are concerned with the young child, most of the published investigations have dealt with pre-school and primary grade children. This is all well and good, and there is still need for more carefully controlled research with young children in this area. But very little research has been reported in which Piaget-type problems have been presented to junior or senior high students. In effect, we know very little - in terms of logical thought processes - about how the secondary school student deals with or interprets his environment.

Piaget designates the 11-15 year age range as the time when human beings can begin to deal with propositional logic and can structure new combinations of mental operations. If we accept the tenet that the development of logical thought is a desirable goal in science instruction, then research devoted to various aspects of logical thinking has implications for science curricula and science instruction.

The purpose of this research was twofold: (1) to replicate selected experiments from The Growth of Logical Thinking; and (2) to examine the feasibility of individual interview techniques for collecting data of this type.

Final results and data will be reported.

Session VIIc - Symposium: The Development, Implementation and Analysis of a Programed Approach to the Teaching of Upper Elementary School Science

Chairwoman: Mary Ann MacDougall, University of Virginia, Charlottesville, Virginia.

1. "The Development and Evaluation of Programed Science Materials with Elements of Critical Thinking," William D. Hedges, Chairman, Department of Education, University of Missouri, Columbia, Missouri; Ertle Thompson, Assoc. Professor, University of Virginia, Charlottesville, Virginia.
2. "The Teaching of Upper Elementary School Science Using Programed Materials Coupled with Student Performed Experiments," Jeff A. Pyatte, Assistant Professor of Education, University of West Florida, Pensacola, Florida, and Mary Ann MacDougall, Associate Professor of Education, University of Virginia, Charlottesville, Virginia.
3. "The Relationship Between Achievement in Science and Mode of Experimentation with Respect to Selected Student Characteristics," William S. Donaldson, Research Associate, Bureau of Educational Quality Assessment and Assistant Professor, Center for Cooperative Research with Schools, College of Education, Pennsylvania State University, University Park, Pennsylvania.
4. "Computerized Model for the Management of Materials Development and Individualized Instruction," Milton D. Jacobson and Mary Ann MacDougall, Associate Professors of Education, University of Virginia, Charlottesville, Virginia.
5. "An Automated Analysis of the Structure of Programed Science Materials: Application to BSCS Units," John Moody, Instructor, University of Virginia, Charlottesville, Virginia.

SUMMARY OF SYMPOSIUM

In 1962 the Bureau of Educational Research, University of Virginia, initiated a series of studies to test the efficacy of programed science materials at the upper elementary school level, coupled with an investigation of the influence of the individual student performance of simple science experiments. The symposium papers are an outgrowth of the research which has focused on the following objectives:

1. The development and evaluation under several conditions of a one-year course of study in programed science - William D. Hedges and Mary Ann MacDougall - A Comparison of Three Methods of Teaching Elementary School Science Involving Programed Learning, CRP 1972, August, 1965.

2. The training and instructional procedures which are effective in adapting programed materials to the educational program - Mary Ann MacDougall, The Teaching of Upper Elementary School Science Using Programed Materials Coupled with Student Performed Experiments, CRP 6-1319, August, 1968.

3. Adaptation to the Computer as a research tool to evaluate programing methods and to identify specific structural features of programs - Methods of Presenting Programed Science Materials to Fourth Grade Pupils of Varying Ability, CRP 6-1310, Mary Ann MacDougall and Milton D. Jacobson.

The substantive contribution of each paper is summarized below.

1. "The Development and Evaluation of Programed Science Materials with Elements of Critical Thinking," focuses on the development and evaluation of the instructional effectiveness of the programed approach under several experimental conditions and the influence of the techniques of critical thinking introduced into the materials.

2. "The Teaching of Upper Elementary School Science Using Programed Materials Coupled with Student Performed Experiments," incorporates the program features within an instructional system, in which the training, supervision, and implementation of the programed-centered approach was carried out in twenty-four upper elementary classes.

3. "The Relationship Between Achievement in Science and Mode of Experimentation with Respect to Selected Student Characteristics," reports on an extended study of the implementation of the programed science approach which examines the possibility of using a knowledge of a student's ability and personality adjustment to prescribe a mode of experimentation.

4. "Computerized Model for the Management of Materials Development and Individualized Instruction," proposes further development of a computerized model for managing the development of programed material and for managing individualized instruction. This model incorporates a flexible multivariable (.25) approach to determine both the readability of materials and to guide the writing and developing of computer-assisted instructional materials.

5. "An Automated Analysis of the Structure of Programed Science Materials: Application to BSCS Units." This paper applies the automated analysis to BSCS programed units and identifies from among twenty-five frame, response, content presentation variables, those program features which contribute to a high error rate and low achievement.

Concurrent Sessions VIII

Session VIIIa - Teacher Education in Science

Chairman: Frank X. Sutman, Temple University, Philadelphia, Pennsylvania.

1. "The Relationship Between the Change in Pupil Control Idealogy of Student Teachers and the Student Teacher's Perception of the Cooperating Teacher's Pupil Control Ideology," Richard A. Roberts, Oklahoma State University, Stillwater, Oklahoma, and Jacob W. Blankenship, University of Houston, Houston, Texas.
2. "A Comparison of the Verbal Behaviors of Pre-Service Teachers When Teaching Students and When Teaching Peers," Earl J. Montague, University of Texas, Austin, Texas.
3. "Patterns of Problem-Solving Behavior Among Prospective Science Teachers," R. G. E. Mitias, Ohio University, Athens, Ohio.
4. "A Correlation of Biology Teachers' Pupil Control Ideology and Their Classroom Teaching Practices," Paul L. Jones, Oklahoma State University, Stillwater, Oklahoma, and Jacob W. Blankenship, University of Houston, Houston, Texas.
5. "An Analysis of Selected Factors Promoting Changes in the Role of the Teacher," Paul N. Hovsepian, Detroit, Michigan.

THE RELATIONSHIP BETWEEN THE CHANGE IN PUPIL CONTROL IDEOLOGY OF STUDENT TEACHERS AND THE STUDENT TEACHER'S PERCEPTION OF THE COOPERATING TEACHER'S PUPIL CONTROL IDEOLOGY

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Stillwater, Oklahoma

and

Jacob W. Blankenship
University of Houston
Houston, Texas

Attitudes and beliefs concerning: (1) teaching, and (2) the control of the students to be taught, play a crucial role in determining a science teacher's classroom effectiveness. This is especially true with the increasing emphasis upon student involvement in science classrooms. The interaction of student teacher and cooperating teacher is considered significant in the socialization of student teachers. The purpose of this study is to examine one set of beliefs, the teacher's pupil control ideology, in an effort to determine how this set of beliefs is influenced by the pre-service teacher's interaction with her cooperating teacher during student teaching.

Using a sample of 108 elementary student teachers, the relationship between student teacher change in pupil control ideology and student teacher perception of cooperating teacher pupil control ideology was examined. Change in pupil control ideology was determined by administering the Pupil Control Ideology Form before and after student teaching. The PCI Form is a twenty-item instrument developed at Pennsylvania State University. It is designed to measure a teacher's pupil control ideology relative to a continuum with humanistic and custodial at its extremes. The student teacher's perception of her cooperating teacher's pupil control ideology was measured using the Perceived Pupil Control Ideology Form, a modification of the PCI Form. Socialization pressure, the difference in student teacher pre-test PCI Form score and the perceived pupil control ideology of the cooperating teacher, was introduced as a measure of the degree of agreement between student teacher and cooperating teacher pupil control ideologies.

Data obtained in this study were analyzed using the t test, Kolmogorov-Smirnov two-sample test, single classification analysis of variance, and the Scheffe' test. The PCI Form scores of student teachers, as a group, increased significantly ($p<.01$) during student teaching. Comparison of two groups, student teachers showing no increase in PCI Form scores and an equal number of student teachers showing the largest increase in PCI Form scores, revealed the two groups to be significantly different on (1) mean Perceived PCI scores ($p<.05$), and (2) mean socialization pressure ($p<.01$). Examination of the differences in mean change in pupil control ideology of student teachers in situations of low, medium,

and high socialization pressure showed the following: the differences in mean change in pupil control ideology for low and medium socialization pressure and for low and high socialization pressure were significant ($p < .01$). The differences in mean change in pupil control ideology for medium and high socialization pressure were not significant.

A COMPARISON OF THE VERBAL BEHAVIORS OF PRE-SERVICE TEACHERS WHEN TEACHING STUDENTS AND WHEN TEACHING PEERS

Earl J. Montague
The University of Texas
Austin, Texas

With the advent of videotape feedback as an integral part of the science methods course at The University of Texas at Austin a question arose concerning the comparability of teaching behaviors exhibited by methods students when role playing with peers and when teaching high school students in the classroom. The problem broadly considered was, "In what ways is role playing with peers a valid reflection of the verbal behavior which would be exhibited when teaching secondary school science students?"

It seemed reasonable that the teaching behavior exhibited when teaching peers would be different than that exhibited when teaching students in a high school science classroom. The validity and usefulness of videotape for evaluation and feedback is limited to the degree teaching behaviors in the two situations are comparable. This study attempted to identify those behaviors which may be comparable in the two situations.

Nine students were enrolled in both student teaching and a secondary science methods course. Each student planned a 20 minute teaching sequence to introduce new content by means of a demonstration. The demonstration and its use were to be designed to not only introduce some new content but also to provide the students with some experience using one or more inquiry skills. The student teachers were videotaped while teaching this lesson to a group of approximately 16 peers. They were then audiotaped while teaching the same lesson to a high school science class. The instrument used to analyze the varbal behavior was Flanders' Ten Category Interaction Analysis. The Scott coefficient measuring coder agreement between three coders was 0.879. The t test in conjunction with a correlation coefficient was then used to detect any patterns associated with individual and group verbal behavior, as well as the significance of any differences between the two situations.

No significance difference in group means was found in the following verbal behaviors: (1) the percent of time devoted to praising, using student ideas, lecturing, and giving directions; (2) the percent of student talk, both solicited and unsolicited; (3) the I/D ratio; and (4) time devoted to extended lecture.

Significant differences at the 0.10 level were found in the following behaviors: (1) the teachers spent more time talking when teaching peers; (2) the I/D ratio was higher when teaching peers. When teaching peers the teachers asked more and longer questions with the differences being significant at the .05 and .01 levels respectively. No criticism was used when teaching peers while 0.55% of the time was devoted to criticism when teaching high school students.

The I/D ratio and the amount of lecturing time for individual teachers were very stable. Individuals changed from one situation to the other in almost all of the Flander's categories, but with few clear patterns. The magnitude of these changes appear to be equivalent to those one might expect to find when a teacher teaches any two classes. This hypothesis will be investigated in subsequent studies.

The verbal behavior exhibited by pre-service teachers when teaching peers is comparable in many respects to that behavior exhibited when teaching secondary school science students. When the difficulties of obtaining secondary school students for use with methods classes is compared with the dissimilarities identified when teaching peers rather than secondary students, it is the author's opinion that role-playing with peers is a reasonable and effective substitute.

(This study has been replicated, and these results will be available for presentation at the convention.)

PATTERNS OF PROBLEM-SOLVING BEHAVIOR AMONG PROSPECTIVE SCIENCE TEACHERS

by

R. G. E. Mities
Ohic University
Athens, Ohio

Careful study of the literature showed an apparent conflict between Dewey's point of view and that of experimental and empirical psychologists regarding problem-solving processes. Most of the samples used by psychologists, however, showed a high degree of heterogenity, and apparent effects of certain experimental conditions. Thus, the purpose of this study was to empirically investigate how a fairly homogeneous sample of prospective science teachers solve problems under a minimum of experimental conditions; and if the subjects behavior was related to (1) the major science field of the subjects, and (2) type of problem to be solved.

The study was designed to test four hypotheses:

1. There are several patterns of problem-solving behavior, for a given problem, within this sample

2. Patterns of problem-solving behavior differ for the same experimental unit from one problem to the other

3. The difference in patterns in solving a given problem is less observable between units which have the same academic major than between units which have different academic majors

4. The difference in patterns among the three subsamples is statistically significant at the accepted 0.05 level.

Each two subjects worked together as an experimental unit to solve two problems: the Cylinder Problem and the Disc Transfer Problem*. The sample included experimental units majoring in biological sciences, comprehensive sciences, and physical sciences. All subjects were college seniors within a given range of age, OSPE score, and number of credit hours in their respective majors.

Prior to collecting experimental data, a six-category observational system was developed (goal clarification, situation analysis, procedure planning, procedure execution, random manipulation, and irrelevant behavior). A trial run was conducted to standardize the problem-situations, recording instrument, time unit, and observer's responses. The experimental data were analyzed in terms of (a) sequence of categories

* These problems are frequently mentioned and widely used in psychological research on problem-solving.

of behavior, (b) frequency of each category, and (c) number of categories.

Graphical analysis of the data showed that four patterns of problem solving processes were identified regarding the sequence dimension. There were also apparent variations in both the frequency and number dimensions*. Thus, the first hypothesis was established. Changing from the Cylinder to the Disc Problem presented different patterns of problem-solving processes by the same experimental units. Thus, the second hypothesis was also established. The data indicated that the third hypothesis could not be established since the difference among units of subsamples was not more observable than the difference within a given subsample.

Statistical analysis of the data** showed that the difference among the three subsamples was not significant at the 0.05 level. Thus, the fourth hypothesis could not be established.

This study was originally planned to help in solving a philosophical-empirical conflict regarding the dominance of a universal pattern of problem-solving behavior (Dewey's). The results of this study seem to shed some light on this conflict. It was also possible to establish a relationship between patterns of problem solving behavior and the type of problem solved. A major significant outcome of the study was, however, the development of a direct and easy to use method of observing and categorizing problem-solving behaviors in order to identify the mental processes involved. This development became necessary, when a thorough review of the literature revealed the absence of a usable and comprehensive instrument.

Problem-solving behavior has been emphasized as a major objective of science teaching. Using the observational instrument of classifying behavior - as developed here - could help educators assess the impact of a given methods course or courses on developing certain patterns of behavior, modifying these, or changing them. Thus, a broad area of research in learning and curriculum development could be systematically and empirically investigated.

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* Slides and transparencies are available and could be used in presenting this paper.

** Kendall's coefficient of concordance W, conditional transitional probabilities, and an analysis of variance design were used.

A CORRELATION OF BIOLOGY TEACHERS' PUPIL CONTROL IDEOLOGY AND THEIR CLASSROOM TEACHING PRACTICES

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and

Jacob W. Blankenship
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Classroom teaching practices that stress active student involvement in classroom experiments and discussions are being advocated in the literature and in curriculum innovations, such as BSCS Biology. Willower has indicated that teachers will tend to resist innovative changes in the school program because they are concerned with pupil control. This study examines the correlation between biology teachers' pupil control ideology and their classroom teaching practices.

Using a sample of 68 high school biology teachers, selected by a stratified randomized process, the relationship between the teachers' pupil control ideology and their classroom teaching practices was examined. The pupil control ideology of the teachers was measured using the Pupil Control Ideology Form (PCI Form), developed at Pennsylvania State University. The PCI Form is a twenty-item instrument designed to measure a teacher's pupil control ideology relative to a continuum with humanistic and custodial at its extremes. The biology teachers' classroom teaching practices were measured using 2,040 completed copies of the Biology Classroom Activity Checklist (BCAC) developed by Kochendorfer and Lee at The University of Texas. The Biology Classroom Activity Checklist is a fifty-three item student report instrument that measures the extent to which classroom practices recommended by BSCS are employed by the teacher in the classroom.

A Pearson product-moment correlation coefficient was calculated between the teacher's pupil control ideology score and the class mean scores on the BCAC. The correlation coefficient was significant (p .01). Correlation coefficients were also calculated between the teacher's pupil control ideology score and the four subscores on the BCAC that measures teaching practices where the teacher plays a major role in the teacher-pupil interaction. The correlation coefficients calculated were significant (p .05).

Curriculum projects that have as a major focus innovative changes that stress active student involvement in classroom experiments and discussions should be aware of the tendency on the part of "custodial" teachers to resist such changes because of concern with control of students. If further studies confirm these findings, teacher training programs should include activities that would tend to lessen the teachers' concern in this area of rigid control of students.

AN ANALYSIS OF SELECTED FACTORS PROMOTING CHANGES IN THE ROLE OF THE TEACHER

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A major problem in the adoption of a curriculum modification such as the Biological Sciences Curriculum Study - BSCS Molecules to Man (Blue Version) - is changing the role of the teacher in the complex teacher-student relationship.

This study was designed to ascertain the correlations of selected factors with the role of the biology teacher in the implementation of the BSCS Molecules to Man (Blue Version) program in the Detroit public senior high schools. These factors include:

1. Teacher's attitude toward the BSCS rationale.
2. Teacher's recency of undergraduate education.
3. Teacher's participation in Board of Education Workshops.
4. Teacher's participation in BSCS Summer Institutes.
5. Teacher's participation in NSF Summer Institutes.
6. Teacher's participation NSF In-Service Institutes.
7. Availability of laboratory facilities.
8. Availability of instructional supplies.

In order to correlate the eight selected factors with the teacher role it was necessary in the study to determine the nature of the teacher's classroom activities. This would reflect the degree to which the teacher's role conformed to the approach advocated by BSCS. The Biology Classroom Activity Checklist (BCAC) developed by Kochendorfer and Lee was utilized for this purpose. [1]

[1]Leonard H. Kochendorfer, "A Comparative Study of the Classroom Practices and Teaching Rationale of High School Biology Teachers Using Different Curriculum Materials," Unpublished Doctoral Dissertation, University of Texas, 1966.

The Blankenship Teacher Attitude Inventory was administered to determine the extent to which the teacher agreed with the BSCS rationale.[2]

A teacher questionnaire was also administered with the Teacher Attitude Inventory to ascertain information relative to factors two through eight (ie., recency of undergraduate training, participation in Board of Election Workshops, etc.).

The sources of data for this investigation included: files and records of the Mathematics and Science Education Department of the Detroit Public School System; seventy biology teachers in the Detroit system with at least two years of teaching experience with BSCS Molecules to Man (Blue Version) and their students.

Analysis of the data revealed that there were correlations between the teacher's attitude toward the BSCS rationale, the teacher's participation in BSCS Summer Institutes, the teacher's participation in NSF In-Service Institutes and the role of the teacher in the classroom as detected by Biology Classroom Activity Checklist.

It is clear from this study that the implementation of a program requiring a change in the teacher's role is significantly related to certain factors. One can expect curriculum change when teachers' attitudes towards the subject matter are changed and when the way in which they relate to their students is changed.

One cannot expect attitudes to be changed substantially on a limited crash program of in-service education. Intensive in-service programs, such as a six or eight week summer institute, are necessary to allow the teacher adequate time for direct involvement with the new material in order to understand the rationale and philosophy of a new program. This should suggest to school systems the necessity of budgeting adequate funds to support intensive in-service teacher education programs. An alternative is to implement co-operative college-school science programs such as those funded by the National Science Foundation.

This study should suggest to the science supervisor the need to promote teacher participation in summer institutes which are directly related to the programs that they wish to implement.

Relative to pre-service education, this study suggests the need to help the future teacher identify and understand the importance of his role in the classroom and its ultimate effect upon student behavior.

The new science curricula have been developed in such a way that a change in the role of the teacher is a pre-requisite to the success of the programs. It would seem research is needed into the role of the biology teacher in the implementation of the BSCS program.

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[2]Blankenship, J. S., "An Analysis of Certain Characteristics of Biology Teachers in Relations to their Reactions to the BSCS Biology Program," Unpublished Doctoral Dissertation, University of Texas, 1966.

School systems which adopt programs on a system-wide basis need to know the kinds of changes in teacher behavior which will be required to insure their success. It is therefore critical to determine which factors in the changing role of the teacher are most significant and by which methods these changes can be achieved. For example, how effective is it to implement the adoption of a new program into a school system by utilizing an in-service training program sponsored by school district or NSF funds? Should school systems urge their teachers to participate in NSF Summer Institutes specifically designed for a newly adopted program to help insure its success? Does the factor of teacher age hinder the change process in the role of the teacher?

It is clearly recognized that the teacher is the key to the success of any program. It appears expedient to investigate the factors which affect teacher behavior in the implementation of a program.

Apart from status studies, there is little research that describes the behavior of the science teacher in the classroom. The information gained from this study may give insight to school systems into the problems of implementation they must recognize when adopting a modified curriculum. It may also hold implications to the designers of curricula in terms of the planning for teacher training programs.

Session VIIIb - Teacher Education in Elementary School Science

Chairman: Addison E. Lee, University of Texas, Austin, Texas.

1. "A Study of Verbal Behavior Patterns in Primary Grade Classrooms During Science Activities," Thomas Charles Moon, California State College, California, Pennsylvania.

2. "Evaluation of the Colorado Elementary Science Project," Jerry G. Horn and Ronald D. Anderson, University of Colorado, Boulder, Colorado.

3. "A Leadership Workshop on Elementary School Science: An In-Depth Evaluation," Dale G. Merkle, Shippensburg State College, Shippensburg, Pennsylvania.

4. "Assessment of the AAAS Science-A Process Approach Institute - A Cooperative College - School Science Project," William S. LaShier, Jr., Kansas State Teachers College, Emporia, Kansas.

5. "Evaluation of an Approach to Graduate-Level Science Education for Elementary School Teachers," Kenneth F. Jerkins, Morgan State College, Baltimore, Maryland.

6. "A Comparison of the Effects of Two Structures of Knowledge on the Application of Science Concepts by Preservice Elementary School Teachers," Lee A. Dallas, Western Washington State College, Bellingham, Washington.

7. "Pre-Service Methods and the 'New' Elementary Science Curricula," Richard N. Avdul, Ohio University, Athens, Ohio.

A STUDY OF VERBAL BEHAVIOR PATTERNS IN PRIMARY GRADE CLASSROOMS DURING SCIENCE ACTIVITIES

Thomas Charles Moon
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California, Pennsylvania

This study was designed to analyze selected examples of verbal behavior patterns in primary grade classrooms during science activities. Thirty-two elementary school teachers within five mid-Michigan public school districts comprised the population under consideration. Sixteen of these teachers taught science in the manner suggested by their respective school districts. Each of the sixteen remaining teaching participants within the experimental population received an in-depth study of the Science Curriculum Improvement Study's teaching methods and materials in a three week workshop during the summer of 1968. This study was designed as a quasi-experimental, time-series analysis and involved a series of science teaching observations that began in April, 1968, and were concluded in March, 1969.

Each science lesson was recorded with easily portable, battery powered tape recorders, and two of the three instruments used in evaluating the study's data were exclusively concerned with information gathered from analyses of the taped lessons. These two instruments were the Flanders System of Interaction Analysis and the Science Teaching Observational Instrument. The third instrument, the Science Process Test for Elementary School Teachers, centered upon an evaluation of teachers' process skills and comprehension of selected science concepts. Statistical treatments used were a repeated measures design of a mixed model analysis of variance, the Friedman two-way analysis of variance by ranks, and t tests for correlated data.

The following are among those findings obtained through analyses of the collected data:

1. those teachers who were exposed to the teaching methods and materials suggested by the Science Curriculum Improvement Study differed significantly from those teachers employing conventional science teaching methods and materials, by demonstrating an increase in the amount of direct teacher influence displayed in verbal behavior patterns during science activities. Apparently this was due to an increased percentage of teacher direction-giving to young children who were actively involved with science materials;

2. there was a pronounced shift in the question preferences displayed by the experimental teachers after the introduction of SCIS teaching methods and materials. The original observations demonstrated a heavy reliance upon low order question types.

After the workshop's conclusion, the teachers demonstrated a much greater preference for higher level questions; and

3. although the SCIS summer workshop's activities seemed to have a definite influence upon the experimental teachers' science presentations during those fall months immediately following its conclusion, the types of science materials used by these teachers also might have contributed to this influence.

Results from data analysis demonstrated that the SCIS teachers used fewer low order questions and a greater percentage of high order questions immediately after the summer workshop. Yet as the school year progressed, the teachers' preferences for question types began to closely parallel their question patterns demonstrated during those months before participation in the summer workshop. Possibly more effort should be placed upon continual supervision and in-service consultation throughout the school year in future implementation projects, in an effort to sustain any gains made during a summer workshop experience.

Some SCIS teachers seemed to expend an unreasonable amount of class time in the distribution and retrieval of science materials. It appears that such elementary school teachers could benefit from systematic instruction in the handling and distribution of science equipment.

A STUDY OF CHANGES IN TEACHING STYLE AMONG TEACHERS IN A CURRICULUM IMPLEMENTATION PROGRAM

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Boulder, Colorado

Jerry G. Horn
University of Colorado
Boulder, Colorado

The purpose of the study was to (1) evaluate changes in teaching style resulting from an inservice education program designed to aid teachers in the implementation of the AAAS or ESS elementary school science program and (2) determine correlates of particular styles of teaching.

All subjects were members of one semester inservice education classes which were taught by fellow elementary school teachers who had participated in a year long program designed to aid them in the adoption of a new science program (AAAS or ESS) and to prepare them to teach other teachers. From among approximately 150 teachers, 28 were randomly selected for a pretest measure and another 28 were randomly selected for a post-test measure. This design, $\begin{array}{llll} R & O & X & \\ R & & X & O \end{array}$, reduced problems of invalidity due to factors such as the testing effect and the interaction of testing and the treatment. The measure of teaching style was a rating on an observation scale designed to measure both verbal and non-verbal interactions among teacher, students and materials. The ratings were based on video-tape recordings made in each teacher's own classroom while using curricular materials written specifically for purposes of the evaluation. Scores on a semantic differential instrument, the Rokeach dogmatism scale, a standardized science achievement test, and the Wisconsin Inventory of Science Processes were obtained and their correlation with teaching style determined.

Differences in teaching style between the pre and post groups were found to be significant at the .01 level. Correlates of teaching style are reported. The study provides evidence that inservice education and assistance in the implementation of new curricular programs, which will result in significant changes in teaching styles, can be provided on a large scale basis through teaching teachers to teach other teachers.

A LEADERSHIP WORKSHOP ON ELEMENTARY SCHOOL SCIENCE: AN IN-DEPTH EVALUATION*

Dale G. Merkle
Department of Elementary Education
Shippensburg State College
Shippensburg, Pennsylvania

New elementary school science curricula are emerging rapidly today. The Michigan State University Leadership Workshop on Elementary School Science was designed to instruct college teachers and school consultants in two of these new curricula: the Science-A Process Approach (AAAS) and Science Curriculum Improvement Study (SCIS).

This Workshop, held at Michigan State University in the summer of 1968, had as one of its objectives the influencing of the participants to promote these curricula and initiate change. It was unique in structure in that it incorporated into the format of the Workshop not just orientation to the programs, but also training in group-process skills, change-agent skills, and a participant-operated workshop which established initial contact for the participants with school systems in their areas.

This study was designed to evaluate the reactions of the participants to the activities of the Workshop and to interpret the effect these activities have on the behavior of the participants after they leave the Workshop.

Pre-Workshop, post-Workshop, and follow-up midwinter conference measures were made on: Knowledge of the two elementary science curricula, knowledge of group-process skills, knowledge of change-agent skills, and attitudes of the participants toward the two new curricula. An assessment was also made of the participants' perceived needs (pretest) and satisfied needs (post-test). Other attitudes were measured also.

Statistical tests were made of the data to determine if meaningful learning took place and to identify correlations between the measures.

Significant differences in knowledge of the two programs, knowledge of group-process skills, knowledge of change-agent skills, and in attitudes toward the two elementary science curricula were found. Investigations of the correlations between measures were made to determine if significant positive relationships between attitude and knowledge, or attitude and satisfaction of needs existed. No significant correlations were discovered with total group comparisons.

When the participants returned to Michigan State University in December 1968 for the follow-up conference, instruments were administered to evaluate both the content of the Workshop and how the participants utilized the Summer Workshop experience.

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* From a study done at Michigan State University under the guidance of Dr. T. Wayne Taylor, with the cooperation of the National Science Foundation Workshop director, Dr. Richard J. McLeod.

Meaningful changes in the behaviors of the participants were noted. Increased in-service activities and an altering of pre-service courses to include more of the AAAS and SCIS philosophies and activities were among the changes reported. The results of this study seem to indicate that workshops can be an effective instrument for producing desired behavioral changes.

ASSESSMENT OF THE AAAS SCIENCE-A PROCESS APPROACH INSTITUTE - A COOPERATIVE COLLEGE-SCHOOL SCIENCE PROJECT

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The goal of the summer phase of the NSF - CCSS project was to conduct a five week institute for 35 elementary school teachers and administrators interested in subsequently implementing the AAAS Science-A Process Approach materials into the first and second grades of their schools.

Prior to the institute, interaction analysis data were gathered while observing 18 of the teachers teaching a science lesson of their own choice. The composite matrix indicated that someone was talking approximately 80 percent of the time, approximately 67 percent of the time it was the teacher talking and roughly 50 percent of the teacher talk was classified as direct influence.

The format of the institute included the activities in the AAAS Guide for Inservice Instruction. In addition, a series of 11 experimental stations were set up the final week and the participants worked on these experiments which required a synthesis of the individual process skills which had been previously developed. In the afternoons the participants observed and worked with four classes of first and second grade students.

Pre- and post-measure scores on the Science Process Measure for Teachers indicated that prior to instruction the participants had a mean score of 11.40 out of a possible score of 25. After instruction, the group mean was 20.86. Mean sub-scores on nine areas provided information as to science competencies which would require additional attention during the academic phase of the project.

Two testing instruments were developed to provide the participants with data as to the process skills already possessed by 137 students entering either the first or second grades within the 13 school districts of the Flint Hills Association. The Set of Competency Tasks, Part B, consisted of 111 tasks selected from existing competency measures associated with 34 exercises in Parts A and B. The Set of Competency Tasks, Part C, consisted of 105 competency tasks representing 24 exercises from Parts B and C. Each of the two instruments would have required 1½ hours to administer. The decision was to use only half the test with a particular child. The test results collected by the teachers were analyzed in terms of where one might begin teaching a particular process, such as measuring. These two instruments are presently being used by the staff to gather additional data on both experimental and control groups for comparison with data to be collected in the spring.

The assessment of the Institute seemed to indicate that teacher competence in science could be significantly improved. Participant observations followed by classroom teaching and then one-to-one teaching appeared to be a valuable aspect of the program. Provision for the participants to spend two days testing in their own schools seemed to clarify, for the teachers, the hierarchial sequences of the AAAS material. The use of videotaped sessions provided additional opportunities to discuss what the teachers might do differently in their own classrooms.

EVALUATION OF AN APPROACH TO GRADUATE LEVEL SCIENCE EDUCATION FOR ELEMENTARY SCHOOL TEACHERS

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A great number of science educators have stated that the colleges and universities are not training elementary teachers to teach sciences properly and that the science background of most elementary teachers is dreadfully low. Some science educators have urged that some way be provided so that graduate credit can be earned in specially designed science courses for those with degrees in areas such as elementary education. As more and more school systems adopt new elementary science curriculum project courses and as more and more school systems make it mandatory that classroom teachers earn a master's degree within a specified time interval there will be an increasing demand for graduate level science education courses emphasizing "structure and content," laboratory activities, the processes of science, and the "spirit" of science as opposed to courses that are best classified as "read-about talk-about courses" with little or no laboratory experiences.

This paper presents a brief overview (through a series of color slides) of what takes place in "Science in the Elementary School," Science 503, an imaginative approach to graduate science education. Science 503 is a required course in the program of study leading to the M. S. degree in elementary education at Morgan State College (Baltimore). The course is both laboratory-oriented and content centered.

Each student, generally an in-service elementary school teacher having more than five years of teaching experience, works in a small team or group of 3-5 persons.

Laboratory activities and group presentations are principal features of the course. Nevertheless, "how" Science 503 is taught is the most significant feature of the course. The classes are very informal. There are relatively few formal lectures. Discussions are directly related to some laboratory activity. The instructor seldom abandons the role of "guide and prompter." Students are urged continuously to "observe, report, and explain or interpret." At the outset of the course the students are told that "devious" methods will be used to create situations in which groups can demonstrate good problem solving techniques and utilize the "processes of science."

The principal focus of this paper is the presentation and interpretation of questionnaire data obtained from one-hundred students who were enrolled in Science 503, "Science in the Elementary School," at Morgan State College (Baltimore) during the period January 1966, - May, 1969.

The questionnaire designed for the survey included 80 structured items organized in clusters relating to course objectives, course content, methods and procedure, and probably outcomes of the course. Also, five

open items were used to elicit suggestions, criticisms, and general comments.

Computerized data processing techniques were used to tabulate, organize, and analyze questionnaire data obtained through the 80 structured items. The Kolmogorov-Smirnov one-sample test and other non-parametric statistical tests were used to determine the extent to which questionnaire responses indicated significant, positive or negative feelings about various aspects of the course. Also, the data were organized for comparative analysis of responses from various groups completing Science 503 during the period January, 1966 - May, 1969. Some strengths and weaknesses of the course have been identified. Very helpful and encouraging suggestions, criticisms, and comments were obtained through the five open items on the questionnaire.

Overall, it appears that most of the students have markedly positive feelings about most aspects of this approach to graduate-level science education for elementary school teachers.

A COMPARISON OF THE EFFECTS OF TWO STRUCTURES OF KNOWLEDGE ON THE APPLICATION OF SCIENCE CONCEPTS BY PRESERVICE ELEMENTARY SCHOOL TEACHERS

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The primary purpose of the study was to determine what effects the organization or structure of a science curriculum would have on the students' ability to apply the concepts comprising that curriculum. A second aspect involved the correlation of *ex post facto* variables with post-test measures of science concept application.

The science concepts presented were, in the author's opinion, subsumed under a single conceptual scheme of science as proposed by the National Science Teachers' Association curriculum committee in 1964. The Test of Concept Application was developed for use in the study. It was designed to measure behaviors of application as defined by Bloom (1956). The sample comprised 101 preservice elementary school teachers enrolled in the College of Education of Temple University in February, 1967. The equivalence of the experimental and control groups was determined by computing t tests to determine the significance of the difference of mean scores on the following measures: (1) the Scholastic Aptitude Test - verbal subscore, (2) the Scholastic Aptitude Test - mathematical subscore, (3) the students' cumulative point-hour ratio at the beginning of the study and (4) pretest scores on the Test of Concept Application. No significant differences were found between any pair of measures.

Each of the experimental groups took part in a science curriculum comprised of the same ten science concepts taught by the author using the same procedures and materials, but varied in the sequential order or structure. One experimental group was exposed to a hierarchical sequence of concepts and the second was taught in a non-hierarchical order. The control group took part in neither the hierarchical nor non-hierarchical curriculum.

The Test of Concept Application was administered as a power test to each group before the study and again, as a post-test. Again t tests were computed to determine the significance of the difference between pretest-post-test mean difference scores of each of the groups.

Pearson product-moment correlation coefficients were computed between the behaviors of application as expressed by the Test of Concept Application post-test scores and the following *ex post facto* variables:

1. Verbal aptitude as measured by the Scholastic Aptitude Test.

2. Mathematical aptitude as measured by the Scholastic Aptitude Test.

3. Background in science.

4. Performance in college as determined by the cumulative point-hour ratio.

5. The college background of the students' parents.

6. Level of dogmatism as measured by the D-Scale Opinionnaire.

No significant differences were found between paired mean difference scores -- gains -- of the experimental groups. The significance of the difference between mean difference scores -- gains -- of each of the experimental groups and gains of the control group was computed at the .001 level and was considered highly significant. The experimental group showed the greater gains. No significant correlations were found between any pair of measures of *ex post facto* variables and Test of Concept Application posttest scores.

1. The subjects' behaviors of application as defined by Bloom (1956) and as measured by the Test of Concept Application were not affected by the structure of knowledge of the curriculum which they had been taught.

2. The techniques practiced in teaching both the hierarchically and non-hierarchically structured science concepts were effective in increasing the students' ability to apply science concepts.

3. Behaviors of application were not affected by the students' (1) mathematical or verbal aptitude, (2) science background, (3) performance in college, (4) level of dogmatism or (5) the college background of the students' parents.

This study has demonstrated that the structure of closely related concepts is <u>not</u> imperative to the formation of individual cognitive structures. The author's recommendation is that research be designed to examine the expanded role of conceptual schemes in structuring teacher education science curricula. Secondly, the importance of structure of knowledge as related to cognitive theory outside the domain of science education should be further scrutinized.

PRE-SERVICE METHODS AND THE "NEW" ELEMENTARY SCIENCE CURRICULA

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The major problem in this research is to determine the status of the teaching of the "new" elementary science programs at the pre-service level by university educators of Ohio, Kentucky, Pennsylvania, and West Virginia.

This study was undertaken to provide a new stimulus into the responsibility involved for those concerned with teacher preparation. Ways and means must be found whereby all teachers will become familiar with contemporary content, methods, and techniques before they assume their first teaching assignment.

It is anticipated that this study will bring a new awareness of the responsibility of other agencies concerned with the preparation of science teachers and with their improvement. Assisting teachers in a continuing education is a mutual responsibility shared by local school districts, state departments of education and professional organizations.

It is also anticipated that this study will result in a "status quo" survey of current practices in science education methods instruction in Ohio to provide a basis by which comparisons and contrasts may be drawn between those institutions reported in the study and those practiced in any given institution. Furthermore, since the Ohio State Department of Education reports that the greatest number of teachers from out of state come from Kentucky, Pennsylvania, and West Virginia respectively, it is felt appropriate to investigate the extent to which professional courses in those states are exerting influences on the instructional programs in Ohio.

Finally, inasmuch as skills of abstract thinking, nonverbal communication, and motor-orientation characterize the new science programs, experience to date seems to indicate that they do provide a way of meeting some of the differences in children's achievement, including the disadvantaged. Thus, the relevancy of this study to Appalachia becomes significant because Ohio, Kencucky, Pennsylvania, and West Virginia are considered a part of that region, and it becomes increasingly important to determine if individuals concerned with teacher education are cognizant of the role the new sciences can contribute to meeting the needs of rural disadvantaged youth.

To help guide the study, the following hypotheses were stated:

1. No significant difference will exist between Ohio and Kentucky, Pennsylvania, and West Virginia university instructors' attitudes concerning the "new" elementary science programs.

2. No significant difference will exist between academic rank and department affiliation in university instructors' attitudes toward the "new" elementary science programs.

3. No significant difference will exist between types and size of methods courses and university instructors' attitudes toward the "new" elementary science programs.

The questions to be answered are:

1. To what extent are the "new" elementary science curricula being taught in the schools within the stated limitations?

2. What factors are associated with the teaching of the "new" elementary science programs?

3. What factors are associated with the degrees of emphasis on the teaching of the "new" elementary science programs?

The data for this study was acquired through a survey of all four states involved offering methods classes in elementary science. There were approximately 190 educators in the sample population.

A questionnaire was designed and revised by five university professors--one of whom is a science educator. The instrument was mailed to the 190 educators. Due to inadequate returns, a follow-up mailing was required. A total of 133 completed questionnaires have been returned, or 70% of the original total.

The statistical analysis of the data involves non-parametric statistics. Computations are being done through the use of the chi square test.

The following limitations have been recognized in this study:

1. This study is limited by its use of the instrument, which by its very nature precludes total objectivity and is at the same time subject to the possibility of non-response.

2. The population is limited to elementary science methods instructors from teacher training institutions of Ohio, Kentucky, Pennsylvania, and West Virginia. Generalizations of the results of this study to other populations in other geographical areas will necessarily be limited.

3. This study included reference to only twelve of the new elementary science programs.

Session VIIIc - Symposium: Earth Science Curriculum Project Research

Chairman: Robert E. Samples, Earth Science Curriculum Project, Boulder, Colorado

Participants: William D. Romey, Earth Science Curriculum Project, Boulder, Colorado.

Marjorie H. Gardner, University of Maryland, College Park, Maryland.

Larry A. Irwin, Earth Science Curriculum Project, Boulder, Colorado.

John F. Thompson, Earth Science Curriculum Project, Boulder, Colorado.

Daniel J. Bauman, University of Colorado, Boulder, Colorado.

ESCP SUPERCEDED: EMERGENCE OF A NEW IDENTITY

William D. Romey
Earth Science Curriculum Project
Boulder, Colorado

From 1963 until 1967 the Earth Science Curriculum Project (ESCP) was involved primarily in the production and testing of curriculum materials in earth sciences for the ninth grade level. Production of ancillary materials (films, pamphlets, and newsletters) continues. A shift in emphasis of the project began in 1968 when "curriculum" was redefined in the minds of the project staff to mean "a set of ideas and goals," as opposed to the original definition, "a set of materials." Many different sets of materials, if used in appropriate ways, can help meet the goals of ESCP.

Three new major efforts related to the implementation and installation of the ESCP curriculum (as redefined) are progressing under the sponsorship of the American Geological Institute. A newly evolving Center for Earth Science Education will coordinate these efforts and replace ESCP.

The first of these is an Earth Science Teacher Preparation Program which will attempt to stimulate and provide support for a network of self-sustaining regional centers for earth science education. (Several centers of this type have already begun to develop.) Among the targets for these centers will be programs for in-service and pre-service training of teachers, training of college consultants and resource people, and the production of training materials designed to help teachers and teacher trainers enter creatively into the process of producing teaching materials compatible with the ESCP curriculum.

The second major effort is an Environmental Sciences Project in which new curriculum materials and teaching styles will be developed for use in helping academically unsuccessful students, especially those in inner-city environments. These materials and teaching styles require special efforts to establish an attitude of trust, mutual respect, and openness between teachers and their students. Ambiguous assignments by the teacher lead to the richness of divergent goals set by students themselves and ultimately lead to learning that is relevant, since the need for it has originated within the students rather than being externally imposed.

The third major program is to help coordinate research in earth sciences education, using the resources of ERIC and other such organizations to identify research completed and in progress, to suggest new avenues of research interest, to offer services in evaluation of research proposals for interested parties, and to perform limited research in certain key areas where no other organizations or individuals happen to be working.

The Center for Earth Science Education will hope to include other programs in earth science education as they become desirable.

TOWARD THE INTRINSIC: AN ALTERNATIVE TO COERCION BY INSTRUCTIONAL OBJECTIVES

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The results of specific generations of research have influenced curriculum makers and teachers in such a fashion that educational objectives have evolved. The evolution of the educational objectives are naturally parallel to the evolving patterns of research. The current generation of instructional objectives are borne primarily of cognitive research. Though efforts have been made to state objectives in the affective domain, little success has so far been met. Affective objectives are still muddled because most evaluative efforts in affective research are highly obtrusive and tend to disturb the very quality that is to be measured.

It is the purpose of this paper to offer a substitute premise in which assumptions are substituted for objectives in the evaluative process. Instead of being concerned with cognitive and affective, this premise considers intrinsic versus extrinsic. In doing so it is found that it is not at all necessary to separate the cognitive and affective.

The introduction of the terms intrinsic and extrinsic is not intended to further confuse instructional pedagese. Instead it is intended to emphasize the position that all objectives as currently being written in any of the courses of instruction that currently prevail are extrinsic in quality.

With more and more emphasis being placed on the humanization of education, serious consideration must be given to the quality of education and instruction that is more intrinsic. With this in mind, it seems that the instructional environment should not be created within a matrix of extrinsic objectives as currently is the practice. Instead the instructional environment should be sculptured from what actually takes place in classrooms. The teacher's role would be guided by a series of general assumptions rather than specific objectives. These assumptions would be structured so as to create an environment in which the student's intrinsic aspirations and potentials would be called into action by the instructional approach. The relationship between teacher and student would be altered because the classroom teacher would be assessing the assumptions by the child's performance rather than the child by his attainment of objectives.

The position that concludes this paper is that those involved in educational research might well devote some time toward the refinement of assumptions that create an instructional environment that is predominantly intrinsic. This activity would seem to represent a departure from the current emphasis in research, which appears to represent the creation of more internally consistent models of research based on the specificity of instructional objectives.

LEADERSHIP DEVELOPMENT

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University of Maryland
College Park, Maryland

During the past two summers, participants in the Leadership Conferences at the University of Maryland have been experimenting with microteaching and human factor analysis experiences interwoven with the study of ESCP themes and laboratory investigations. Such conferences have many goals. One is to develop a cadre of highly effective resource personnel for curriculum projects. Another is to encourage rational risk takers, responsible individuals who are willing to take a chance professionally when there is something of sufficient importance to be accomplished. The encouragement is an important means of stimulating innovation and new directions in science education. Other goals of such conferences include finding means of modifying teacher behavior and of helping individuals become more introspective, more insightful, more sensitive to their own talents, short comings, and impact on their students and colleagues.

Evaluation of the conferences has been done during, immediately after, and six months following the conferences. In addition, future follow-up studies are anticipated two years and five years from now to determine the impact of these conferences upon the personnel who attended and on curriculum implementation. These studies will also try to determine if the contribution of these people to science education is usual or in any way unusual.

After preliminary review of these conferences, certain aspects of microteaching, supervisory experience, and human factor analysis are being incorporated into our pre-service and in-service programs for secondary school teachers. These same techniques are being tried and have high potential value for the preparation of college level teachers through the teaching assistantship programs in academic departments.

A COMPARISON OF THE EFFECTS OF OBSERVATIONAL LEARNING AND SELF-RATING ON THE ACQUISITION AND RETENTION OF A QUESTIONING BEHAVIOR BY ELEMENTARY SCIENCE TEACHER TRAINEES

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Austin, Texas

The purpose of this study was to compare two modes of teacher training. The first, observational learning using live or videotape models has considerable research to recommend it. Its limitations are that the arrangement of conditions for this type of training is frequently difficult or impossible, and the cost high. An alternative, self-rating combines elements of modeling theory and operant conditioning, can take place in a science methods classroom, and is inexpensive. But before advocating one or the other method, it is necessary to examine their relative effect on the acquisition and retention of a criterion behavior.

Twenty-one preservice elementary teachers were randomly assigned to two treatment groups: a film-mediated modeling group and a self-rating group. Ss took a pretest on which they were asked to generate as many observation-classification questions as they could, using a given set of AAAS science materials. Subsequently, the film-mediated modeling group viewed a model of the questions to be generated while the self-rating group rated their pretest performance using a rater protocol as a guide. The independent variables here were observation of a film-mediated model of the behavior to be acquired, or rating a previous performance of a lesson taught. The dependent variable was the generation of observation-classification questions in writing. Each S was exposed to the training twice and to the performance measure before and after training and two weeks after the final training session. Time of exposure to training methods and criterion tests were equated. Three raters rated the behaviors generated by Ss with an interrater reliability of .97.

A two-way analysis of variance over three trials and two treatments in each trial showed that both training methods produced significant acquisition of the criterion skill over the training period. There were significant changes from trial 1 to trial 3 scores for subjects within groups ($p = < .05$). Furthermore, the retention test indicated that the self-rating group dropped in performance significantly after two weeks ($p = < .05$) whereas the film-mediated modeling group retained its level of performance.

It might be concluded that in cases where cost is a consideration, facilities limiting, and the task to be acquired is a relatively simple verbal behavior, self-rating training procedures in a science methods course are a practical and effective alternative to film-mediated modeling procedures. If, however, participants will not have a chance

to practice the acquired skills after training and be reinforced for their behaviors, modeling procedures appear to produce a greater retention of the acquired skills.

This study is part of a continuing line of research attempting to identify effective task and method variables in the instruction of science teachers. It is leading toward a model of science teacher education which considers aptitude x task x method variables.

THE EFFECTS OF SELECTED TEACHING METHODS ON CREATIVE THINKING, SELF-EVALUATION, AND ACHIEVEMENT OF STUDENTS ENROLLED IN AN ELEMENTARY SCIENCE EDUCATION METHODS COURSE

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This investigation has explored the effects of a modified elementary science education methods course on students' creative thinking, self-evaluation and achievement. Thirty juniors and seniors enrolled in Science Education 270 at Colorado State College for the Winter Quarter, 1969, comprised the experimental group for the study. Thirty-nine students enrolled in another section of the course were involved as a control group.

Lecture-discussion meetings were essentially the same for both groups. Laboratory sessions and related written assignments, however, varied. Control group laboratory sessions were organized around the standard course laboratory manual and related researcher-constructed Laboratory Supplements. Experimental group laboratory sessions were concerned with the same science topics, but certain creativity-training activities were also included. These were: (a) brainstorming; (b) inquiry development sessions; (c) morphological analysis of problems; and, (d) researcher-developed Invitations to Creative Thinking written exercises.

Pretest and posttest scores of fluency, flexibility, and originality of idea production were gathered for both groups through administration of the Torrance Tests of Creative Thinking (TTCT). Pretest and posttest achievement scores were determined through administration of the Science Education Achievement Test (SEAT), modified by the researcher from a test developed by Tillery Analysis of covariance was used to determine whether significant differences in fluency, flexibility, originality, and achievement occurred from pretest to posttest between the groups.

Two researcher-constructed instruments were administered at the conclusion of the course: The Self-Evaluation Inventory (SEI), providing data regarding students' ratings of their achievement of the forty-seven cognitive and eleven affective behavioral objectives specified for the course; and, the Course Evaluation Instrument (CEI), providing data on students' ratings of various portions of the course. A t test was used to determine any differences between group ratings of each of the SEI and CEI items.

The Pearson product-moment statistic was used to determine any correlation between the TTCT and SEAT posttest scores.

The experimental group was found superior to the control group in gains in fluency, flexibility, and originality TTCT scores at a highly significant level. No difference was found between groups in SEAT scores. The SEI data indicated essentially no differences between groups in self-ratings of achievement of cognitive course objectives, but the experimental group was significantly higher in ratings of affective objectives. In CEI ratings of twelve components of the methods course, no differences were found for ten of the items, while lecture-discussion sessions were rated significantly higher by experimental subjects, and the test-construction assignment was rated significantly higher by control subjects. A significant negative correlation was found between TTCT and SEAT posttest scores.

The findings of this study substantiate previous investigations indicating creativity can be improved. Entire courses in creativity-training, however, seem unnecessary. It appears creativity-training may be included as a portion of an existing elementary methods course and effect gratifying creativity improvement with no loss in subject-matter achievement. Coupled with this, the significant affective gains found associated with the inclusion of creativity-training in a modified methods course suggests methods courses could be improved by including creativity-training as a regular course of action. Some interaction may be operative between students' improved creativity and affective gains.

The significant negative correlation between creativity and achievement test scores suggests the highly creative methods course student may be discriminated against by standard subject-matter evaluation instrument orientation. Probably evaluation instruments should involve higher levels of thought, including creativity.

As a corollary to this investigation, specification of cognitive and affective behavioral objectives, and the application of these in student self-evaluation has been a promising technique.

AN ANALYSIS OF A METHOD FOR IMPROVING SCIENCE PROBLEM-SOLVING ABILITY POSSESSED BY PROSPECTIVE ELEMENTARY TEACHERS

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This study was designed to determine if the critical analysis of science research papers improved the science problem-solving ability of the prospective elementary teacher. Further, an effort was made to determine: (1) the relationship between the student's problem-solving ability and his reading ability and (2) the joint effects of his reading ability and the instructional methodology on his problem-solving ability. A secondary goal of this study was to determine if relationships exist between the ability to solve problems in the laboratory and the student's ability to think critically, to recognize problems and to select modes of attack.

The investigation was limited to six laboratory sections of a science methods course for prospective elementary teachers at a midwestern state university. Three laboratory sections containing eighty-five students were randomly assigned to the control group, and three laboratory sections containing eighty-three students were similarly assigned to the experimental group.

Both the experimental group and the control group followed an inquiry oriented plan for laboratory instruction. Additionally, in the experimental sections, five research papers drawn from the history of science were critically analyzed. Copies of each research paper and the accompanying guide questions were distributed to the students. Subsequent class discussion was based on student responses to the guide questions. Evaluation involved the Nelson-Denny Reading Test, the Watson-Glaser Critical Thinking Appraisal, the Andersen Problem Recognition and Attack Skills Test and the investigator's laboratory performance test. These instruments were administered to all the experimental and control laboratory sections.

Analysis of variance was used to compute the significance of the difference between: (1) the experimental group and the control group and (2) the high reading ability group and the low reading ability group. In addition, this same statistical procedure was used to determine the interactive effects of the two variables, instructional methodology and reading ability, on problem-solving ability. The Pearson-r was used to calculate the correlation coefficient between the student's scores on the investigator's laboratory performance test and: (1) the scores on the Watson-Glaser Critical Thinking Appraisal and (2) the scores on the Andersen Problem Recognition and Attack Skills Test. The F ratio and the r ratio were compared to appropriate values in published tables at the .05 level of significance.

Within the limits and conditions of the study, the following results were obtained: (1) the students who critically analyzed the science research papers and the students who did not participate in this instruction showed no statistically significant difference in their problem-solving ability; (2) reading ability was not significantly related to the student's problem-solving ability at the end of the experimental treatment; (3) the joint effects of the student's reading ability and the methodology did not significantly influence his problem-solving ability; (4) there was a significant correlation between the student's ability to solve problems in the laboratory and his ability to recognize problems and to select modes of attack.

Although the statistical analyses of the data did not indicate that the critical analysis of science research papers improved the prospective elementary teacher's problem-solving ability, it seems possible that the procedure may have developed aspects of the problem-solving ability not measured by the instruments used in the study.

INSTRUCTION ON QUESTIONING

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Baltimore, Maryland

This investigation included studying the effects of two instructional strategies on three aspects of preservice science teacher behavior: (1) the number of divergent and evaluative questions asked; (2) the proportion of divergent and evaluative questions asked; and (3) the total number of questions asked. Both strategies included the same programmed instructional booklet; however, the instruction that followed the reading of the program differed among strategies.

A pretest was used to measure the entry behavior of preservice science teachers in four experimental groups. Following instruction, two posttests were made, each following one phase of instruction. The first phase included reading the instructional program, a handout describing the categories of questions, and either categorizing or designing questions. The second phase of instruction included a conference during which each preservice science teacher discussed his questioning behavior with the instructor. A fifth group (control) did not receive formal instruction on questioning, but did meet in conference with the instructor and received the handout describing the categories of questions used during this study. The investigator categorized questions from audiotape recordings made of 15-minute science lessons presented by the preservice science teachers. For purposes of data analysis, questions were categorized into either of two categories: (1) cognitive-memory and convergent; or (2) divergent and evaluative.

Analysis of variance and t test were the experimental designs used to test the significance of the variables studied. Instructors and proportion of divergent and evaluative questions asked during the pretest were used as covariables.

1. Instruction in classifying questions asked and instruction in designing questions significantly and positively affected both the number and proportion of divergent and evaluative questions asked.

2. Instruction in the use of divergent and evaluative questions significantly and negatively affected the total number of questions asked.

3. Conferences between the instructor and the preservice science teacher were more effective in affecting the divergent and evaluative questions asked when used in conjunction with the formal instruction presented during this investigation.

Divergent and evaluative questions focus attention on something more than regurgitation of factual information and produce divergent and evaluative thought in students. The implication that appears to be suggested from this research is that instructors can use either instructional strategy to increase the use of divergent and evaluative questions asked by preservice science teachers.

Session VIb - Children's Learning in Elementary School Science

Chairwoman: Rose Lammel, Wayne State University, Detroit, Michigan.

1. "Differences in Science Concepts Held by Children from Three Social-Economic Levels," Carol Klein, College of St. Catherine, St. Paul, Minnesota.
2. "The Image of the Scientist Among Elementary and Junior High School Students," Donald J. Schmidt, Fitchburg State College, Fitchburg, Massachusetts.
3. "Pictures of Scientists as Drawn by Children and Their Concept of Science," Kenneth W. Uhlhorn, Indiana State University, Terre Haute, Indiana.
4. "A Comparison of Categorizing Ability in High and Low Socio-economic Status Kindergarteners," Roger Johnson, Jr., University of Minnesota, Minneapolis, Minnesota.
5. "Science Classificatory Dimensions and Rules Used by Children," Leroy B. Weinbrenner, Trinity College, Deerfield, Illinois.
6. "A Comparison of Individualized and Group Instruction in Science: Effects on Third Grade Pupils," James Joseph Gallagher, Educational Research Council of America, Cleveland, Ohio.

DIFFERENCES IN SCIENCE CONCEPTS

HELD BY CHILDREN FROM THREE SOCIAL-ECONOMIC LEVELS

Carol Klein
College of St. Catherine
St. Paul, Minnesota

The purpose of this study was to determine if children from three social-economic groups differed in their understanding of selected science concepts and in the methods they would suggest to find answers to questions associated with the concepts.

Fifteen St. Paul, Minnesota elementary schools selected for the study were classified as serving high, middle, or low social-economic groups on the basis of information obtained from the city offices and the administration of the metropolitan school district participating in the study. Only schools that served a single social-economic group and that had no racial minority groups were included.

Science questions based on concepts selected from the system's basic text were tested in another suburban school district (comprised of children from the middle and lower social-economic groups) to determine their clarity and discriminating power. In addition to the fifteen questions finally selected for the test, the students were asked to suggest a way of finding out answers to each question whether or not they knew the answer.

In the May, 1968, pilot study, the test was administered individually by the researcher to sixty third grade children; their responses to the questions were tape recorded. Later, forty of these children took the test in written form. The questions were read aloud to minimize the possible consequences of different reading abilities. The means and standard deviations for the written and taped test scores were very similar and correlated .87 to .90. The test-retest reliability was, therefore, at these values. These results were believed to justify using a written test for the main study. In the fall of 1968, the written test was administered by the teachers in the same manner as the pilot study written form, providing data from 310 fourth grade students in fifteen classes in nine schools.

Questions and Results

Question	Tested by	Results
1. Is there a significant difference between the mean I.Q.'s of the three social-economic groups?	One-way analysis of variance Newman-Keuls Test	Significant difference at .01 level between each group. $\bar{X}$ = High 116.13, Middle 107.41, Low 99.72.

Question	Tested by	Results
2. Is there a significant difference between the mean scores on the test of scientific understanding when only raw scores are considered?	One-way analysis of variance Newman-Keuls Test	Significant difference at .01 level between each group. $\bar{X}$ = High 7.04, Middle 6.14, Low 2.71.
3. Is there a significant difference between the mean scores on the test of scientific understanding when the raw scores are adjusted for I.Q. differences?	Co-variance analysis Newman-Keuls Test	Significant difference at .01 level between low and high, 3.03-6.29; low and middle, 3.03-6.05.
4. Are there differences in the kinds of answers suggested by the three groups to the questions "How could you find out?"	Differences by percent	Major differences in Experiment-Observation. Selected least by low group. Low often suggested no answers.
5. Are there differences in the number of correct responses given by the three groups to individual test items?	Chi-square analysis	Significant at .05 level for 13 of 15 items. Low had least correct on each of the fifteen.

The children from the three social-economic groups differed in their mean level of understanding of the science concepts and in the methods they suggested to seek answers to these questions. When the mean score of each group was adjusted for I.Q. differences, the low social-economic group scored significantly lower than the other two groups.

If differences in levels of understanding science are associated with social-economic factors, as this study would seem to indicate, using the same text and materials for all schools may not be an effective teaching method. If science education is to be concerned with both the processes and products of science, a curriculum planned for children in the lower social-economic group may need to include more opportunities for experiment and observation.

The close agreement between the interview test and the written test read to the students to minimize reading problems suggests that the written test may be used in other research where large groups of children are to be tested.

THE IMAGE OF THE SCIENTIST AMONG ELEMENTARY AND JUNIOR HIGH STUDENTS

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In 1957, Mead and Metreaux reported on the image of science and of the scientist among high school students. This report and several that have been given since that time have indicated that the "image" is something other than might be desired by those of us interested in science and science education.

In studying the understanding of science, this author and many others have made use of testing instruments such as the Test On Understanding Science. The very nature of this instrument limits the study to students with maturity and a rather well developed vocabulary. Other attempts have been made by this author and others to study the "image" from written paragraphs but again the limiting factors are the students themselves, their ability to express their image on paper in paragraph form. Thus, most of the study of the understanding of science deals with students from grade 7 through college.

Despite the limitations of the previous studies, there is some evidence that a great deal of the attitude toward and the image of science is developed during the elementary school years. The problem then is simply, how can the image of the scientist among the younger students be studied? Of course, the goal of the study is to find out what the image of the scientist really is.

Preliminary attempts to solve the problem involved asking the elementary and junior high students to say what characters they have seen on television seem to look and act like scientists. Another approach was to ask them to say what person in their personal contact life looks and acts like a scientist.

Based upon the data collected during the preliminary attempts described above, an instrument was devised to be used by the elementary and junior high student to visually create his mental image of the scientist. With the aid of an artist and by the use of many photographs, a series of transparencies were developed that were so constructed as to allow the student to create the type of person he wanted to represent his image of the scientist. For example, one transparency would be the head, another a body, another a specific type of laboratory surrounding, etc. By simply superimposing the various transparencies the student builds the picture of the "scientist".

The results of the questioning about characters that act and look most like scientists are quite shocking. Over 90% of the persons indicated could in no way be considered to be scientists, or for that matter be considered to be involved in any activity remotely related to science. The results of the "image creation" portion of this study were equally disturbing. Most young persons think of the scientist as being

at least middle aged, wearing a white coat and being a bit odd. This study indicates that it is possible to find out something about the image of the scientist among elementary students who do not have the ability to respond to more sophisticated paper and pencil examinations. Personal interview techniques utilizing the visual representation technique described above proved to be most useful.

PICTURES OF SCIENTISTS AS DRAWN BY CHILDREN AND THEIR CONCEPT OF SCIENCE

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When science educators attempt to discover the concept elementary school age children have of science, they are faced with many problems. The major problem seems to be the inability of primary and some intermediate children to express themselves verbally.

This study uses the drawings of scientists made by approximately 2800 elementary children to investigate their concept of science and scientists. The major assumptions being that what the person in the picture is doing is science and that background experiences the children have had that relate to science and scientists will be identifiable in the pictures.

Each picture was analyzed to see which of thirty-five different characteristics were included. Generally the characteristics could be grouped into the following categories:

1) the appearance of the scientists;

2) the laboratory and the materials found there; and

3) the areas of science which are represented.

The grade, school, and sex of the child who drew the picture was also included with the analysis.

The percent of the total number of children at any grade level who included in their drawing the same characteristic comprised the statistic used as a basis for generalizing at that grade level. If 50% or more of the children at a given grade included a characteristic in their picture it was assumed that this could be considered typical for their grade. In addition, the ten most frequently drawn characteristics were also noted for each grade.

A chi square test was used to analyze the differences between the numbers of children at each grade who included a specific characteristic of a scientist. This test was also used to investigate the difference in the number of boys and girls at the same grade level who included the same characteristic on their drawings.

If a concept can be defined as an understanding which is based on past experiences, then one can assume that the children's pictures represent their science-scientist understanding based on the experiences they have had. If this is the case, what are the experiences which have given the children the concepts they have illustrated on their drawing and when in their educational process have these experiences played a significant enough role to influence their drawings?

Generally, the results of this investigation indicate that the stereotyped scientist of the television cartoon and comic book predominate the child's concept of science and scientist from grades 2 through 6. Also, at these grade levels, that he is a chemist and works in a laboratory filled with glassware and chemicals. The students in the primary grades indicate only that the scientist is a person and, more specifically, a man. This study has also implied that the concepts children have of science and scientists are cumulative becoming more complete as the children progress through the grades.

It should be pointed out that there has been no attempt to analyze the artistic talent or ability illustrated by the children's drawings. No attempt has been made to obtain any of the children's explanations of what they have drawn.

The generalizations made in this paper are based on the drawings of students of in-service teachers who were involved in extension classes taught by the author at several extension centers of Indiana State University. No attempt was made to control the instructions given to the students other than that they were to make drawings of scientists or was any time limit given for making the drawings.

The technique used in this study has many possibilities in investigating children's concept of science and scientists. It is a non-verbal technique which can be used successfully in the primary grades as well as in the intermediate grades. The potential of this mode of investigation is one which science educators should not overlook.

A COMPARISON OF CATEGORIZING ABILITY IN HIGH AND LOW SOCIOECONOMIC STATUS KINDERGARTENERS

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Two studies were conducted to investigate (1) the basic mental operations of young children which allows them to organize the sensations received from their environment and (2) the differences and similarities of children from differing socioeconomic status backgrounds in their ability to perform these organizations. The studies were conducted in the spring of 1967 (study A) and spring of 1968 (study B). Since study B was an extension and replication of study A, the designs were basically identical and they will be described together with any differences pointed out.

The samples were drawn from the Oakland School District (Oakland, California) on the basis of socioeconomic status data collected by the district. The criteria for SES involved family income and breadwinner's occupation, (also collected were the mobility of student populations, average unexcused absences, and the racial composition of the schools). The samples were randomly selected for each study from eight kindergartens with four different teachers (study A: N=40; study B: N=60).

The design used was the Posttest Only Design with the independent variable being socioeconomic status. Comparisons were made in connection with SES, Sex, the nature of the attribute, the number of attributes present, the strategies used, and the horizontal development of categorizing. The dependent variable of categorizing ability was measured with four tests modified from the Lawrence Lowery Apperception Tests (Lowery in press for spring 1970, AERJ) and a follow-up interview using concrete materials (attribute blocks). The testing required the student to recognize and compare attributes for similarities and to categorize them into groups. They were administered to groups of four or five students with one out of every five students then being interviewed on the basis of his previous responses. The students interviewed were systematically selected to represent high, medium, and low scorers. The data were analyzed statistically using the analysis of variance with repeated measures, and analyzed descriptively using observations and audiotapes.

The High SES kindergarteners demonstrated more ability to consistently categorize on attribute resemblance than the Low SES sample (X=.05). Although categorizing is a cognitive process and extreme care was taken in the research, affective variables (self-image, motivation, etc.) undoubtedly had some effects on the scores. The cognitive similarities were numerous with both groups showing very similar strategies, trends in the test scores patterns, preference of attributes and types of errors. These results indicated a similar cognitive development in categorizing with the possibility of a slower

pace in the Low SES sample. There were no differences evident between boys and girls as total groups or within SES groups.

In comparing the students ability with different attributes, both SES groups demonstrated preference for the attribute shape over size and pattern. Any differences in ability between size and pattern were not significant (x=.01). Comparisons of ability to deal with single, double, and triple attribute problems were obscured by the attribute preference data.

All of the kindergarteners were able to categorize at some level using almost exclusively a "perceptual focusing" strategy involving a seemingly random choice of a focus picture and a one to one search for identical pictures. The task was extremely simplified when the focusing picture was supplied indicating the importance of the initial focusing part of the strategy and being able to shift focus if not succussful. The kindergarteners also displayed ability in discrimination, but some confusion concerning equivalence which is understandable as the child has the natural sensory equipment to differentiate phenomena, but equivalence is an intellectual invention of man which the child is developing.

Since the mastery of categorizing is both necessary and natural and begins with birth not with kindergarten, it would seem profitable to promote programs which make use of less dominant attributes than shape or color, emphasize multiple ways of grouping and which grouping is most efficient, and perhaps make the process of categorizing a more conscious one.

SCIENCE CLASSIFICATORY DIMENSIONS AND RULES USED BY CHILDREN

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This study was designed to identify the classificatory dimensions and rules used by children when grouping science-related objects; to compare these classificatory dimensions and rules with the classificatory dimensions and rules used in science; to determine the relationships between the types of classificatory dimensions and rules used by children, and their sex, ability level, and neighborhood type; and to identify any trends existing over grade level in the classificatory rule usage by children.

One rural school, one suburban school, and one inner-core urban school were selected for this study. Within each school two boys, one each of high and low ability, and two girls, one each of high and low ability, were selected at each grade level, one to eight.

The data were gathered in individual interviews, each child being asked to group sets of science-related objects into subsets. The data were comprised of observations of the groupings formed by the children and of responses by the children to the investigator's queries concerning the nature of the dimensions and rules used for the establishment of the subsets.

The classificatory behavior of the children in this study is described as follows:

1. About three-fourths of the subsets formed by the children were based upon dimensions which are also used in designing science classificatory concepts.

2. About half of the subsets formed by the children were based upon a Gross dimension such as color, shape, size, or texture. The other half of the subsets were formed using dimensions classified as Inferred, Fine, Phenomenalistic, Environmental, Compositional, and Appellative. The children formed only small numbers of subsets using dimensions classified as Behaviorial, Utilitarian, Derived, and Theoretical.

3. Every child established subsets using the Gross dimension and more than half of the children established subsets using the Environmental, Phenomenalistic, Fine, Inferred, Compositional, and Appellative dimensions.

4. The children used the one attribute rule in forming 95 percent of their subsets and the conjunction of dimensions rule in forming five percent of their subsets.

5. Two-thirds of the children's acceptable groupings were based on one dimension.

6. Comparisons among the sex subpopulations, the ability level subpopulations, and the neighborhood type subpopulations indicate that, with some exceptions, the boys and girls exhibited similar grouping behaviors; the high and low ability children exhibited similar grouping behaviors; and the rural, urban, and suburban children exhibited similar grouping behaviors.

7. There were irregular increases with grade level in the number of subsets formed, in the use of the Appellative and Inferred dimensions, and in the number of one dimension and dichotomous groupings formed by the children. Above grade four the usage of different acceptable dimensions or the usage of abstract dimensions did not increase.

8. Comparison of the sex, ability level, and neighborhood type subpopulations at each grade level again revealed that the subpopulations of children exhibited similar grouping behavioral trends.

A COMPARISON OF INDIVIDUALIZED AND GROUP INSTRUCTION IN SCIENCE: EFFECTS ON THIRD GRADE PUPILS

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This study was designed to examine differences in pupil behavior and achievement resulting from an individualized instructional approach and the more traditional, teacher-directed, group instruction.

Four groups of fifteen pupils were randomly selected from public school third graders in a middle-class suburban community. Pupils from one of the groups were given, individually, a two lesson instructional sequence using the audio-tutorial mode. Pupils in a second group were given the same two lesson sequence in the familiar, teacher-directed, group mode. Pupils in the third group were given the first lesson of the sequence individually, in the audio-tutorial mode and the second lesson as a teacher-directed group. The fourth group served as a control and received no instruction.

The lessons were adapted from Interaction, a unit prepared for primary school children by the Science Curriculum Improvement Study. The lessons followed the instructional plan outlined by the unit's writers; that is the first lesson provided an opportunity for "exploration," and the second focused on "invention" and "discovery." The individualized lessons and those in the group mode paralleled each other as closely as possible.

Three types of data were collected:

1. Achievement Data - a variety of posttest data on pupils' understanding of, and ability to apply the concept of interaction.

2. Process Data - information about pupil behavior during the instructional sequence. Included are data on specific tasks children were required to perform and a videotape record of all overt pupil behavior during the instructional sequence.

3. Pupil Background Data - scores on standardized tests which are part of each child's permanent school records.

Analysis of the process data showed marked differences in the nature of the experience which children undergo in the two instructional modes. In the individualized mode, pupils attended chiefly to the

concrete materials that embodied the phenomenon which was being studied; whereas, in the group setting, the child's attention was shared among the materials, the teacher, and other pupils. The individualized setting, provided in this study, seemingly allowed pupils freedom from distraction while examining materials, making observations, and reflecting on what was observed. By contrast, the group mode was characterized by greater inter-personal interaction. Achievement data showed tendencies which were compatible with pupils' experiential differences.

This study constitutes an early step in a needed examination of the effects of different instructional modes on learners. These preliminary data suggest that the choice of instructional mode may sharply alter the nature of the learning experience and consequently influence the instructional outcomes.

Session VIc - Symposium: The Educational Encounter: Toward a Theory of Teacher Education

Chairman: Howard L. Jones, University of Houston, Houston, Texas.

Speakers: E. Glenadine Gibb, University of Texas, Austin, Texas.

Glen McGlathery, University of Colorado, Boulder, Colorado.

Alan Steinbach, St. John's College

Chester Raun, Temple University, Philadelphia, Pennsylvania.

David Butts, University of Texas, Austin, Texas.

Discussants: J. M. Atkin, University of Illinois, Urbana, Illinois

Gene E. Hall, University of Texas, Austin, Texas.

GENERAL SESSION B

Presiding: Alan M. Voelker, University of Wisconsin, Madison, Wisconsin.
Speaker: R. Bruce Lindsay, Brown University, Providence, Rhode Island, "A Unified Approach to Science Teaching"

The tremendous impact of science on society suggests that a more effective grasp of this important way of looking at human experience should be provided to the students passing through our educational system. The present need is made all the greater by a misunderstanding of the fundamental nature of science now prevalent in the general population. Science is all too commonly confused with technology, a related but essentially different discipline.

Science education is indeed currently making substantial progress through the development of new curricula in general science in clementary and secondary schools throughout the nation. However, there still exists the strong tendency to follow the general science courses with year courses in specific branches, i.e., physics, chemistry, and biology, in the last two years of high school. The same sort of program persists in large measure in introductory science courses in colleges and universities, even for those students who do not intend to embark on professional careers in science. This seems unfortunate, since in such specific subject matter courses the real significance of science may easily get lost amid the factual details of the separate branches. The fundamental unity of science is usually entirely overlooked, as well as its relations with other ways of looking at and attaching meaning to human experience, namely the humanities and the social studies.

It is the purpose of the present paper to suggest the introduction into advanced secondary school and elementary college programs of courses of study which will emphasize science as a method for the description, creation and understanding of all aspects of human experience. Such a course will necessarily involve a thorough examination of each category in the method, along with a wealth of illustrations from all branches of science. It will stress the nature of scientific theorizing, the historical development of scientific concepts, the behavior patterns of scientists, the unity of science, the relations of science with technology and the state and the influence of science on human thinking and activity, past and present.

Such courses will inevitably demand changes in the methods of training science teachers for the secondary schools, as well as some modification in the outlook of college teachers. They will also entail the design and preparation of new educational materials, including more appropriate written materials, audiovisual aids and equipment for simple but effective demonstrations and laboratory experiments.

Through such courses of study as are suggested here, it is hoped that our young people will ultimately gain a better understanding of the meaning of science and its role in our civilization.

Concurrent Sessions VII

Session VIIa - Instruction and Evaluation in Elementary School Science

Chairwoman: Katherine E. Hill, New York University, New York, New York.

1. "An Approach to Concept Assessment," Edward L. Smith, Southwest Regional Laboratory, Inglewood, California.
2. "Group Achievement Tests Developed for Two Basic Processes of AAAS Science-A Process Approach," Jean Beard, San Jose State College, San Jose, California.
3. "Development of Test Items Related to Selected Concepts within the Scheme the Particle Nature of Matter," Rodney L. Doran, State University of New York at Buffalo, Buffalo, New York, and Milton O. Pella, University of Wisconsin, Madison, Wisconsin.
4. "Development of the Science Curriculum Assessment System (SCAS): Part One, Introduction and Interview Protocols," Darrell G. Phillips, University of Iowa, Iowa City, Iowa, and Charles C. Matthews, Florida State University, Tallahassee, Florida.
5. "Development of the Science Curriculum Assessment System (SCAS): Part Two, Classroom Observational Systems and Conclusion," Charles C. Matthews, Florida State University, Tallahassee, Florida, and Darrell G. Phillips, University of Iowa, Iowa City, Iowa.

AN APPROACH TO CONCEPT ASSESSMENT

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Southwest Regional Laboratory
Inglewood, California

To answer questions about the role and placement of abstract concepts in the elementary school science curriculum, techniques are needed for exploring or mapping out children's versions of them. The study reported here was an attempt to develop a comprehensive approach to concept assessment.

To guide the development, a notion of what was meant by <u>concept</u> was adopted. Using this notion of concept, a domain was defined for the concept of heat and a framework for generating and describing <u>assessment tasks</u> was developed. This framework mapped out the conceptual territory to be assessed by defining classes of situations within the domain of the concept and specified the kinds of operations the children would be required to perform for the assessment (describing, predicting, and accounting for). On the basis of responses obtained in preliminary interviews with first and fifth graders, a framework for classifying and describing <u>children's responses</u> was developed. This framework distinguishes between the following general types of response as well as content specific subclasses of each.

1. Precausal - Responses employing animism or artificialism.

2. Mechanistic - Responses employing an unobserved, nontheoretical process to account for a phenomenon.

3. Concrete - Responses referring to an observable object or substance as a causal agent.

4. Theoretical - Responses employing theoretical constructs.

A set of thirty-five tasks covering a limited portion of the domain of the concept of heat was prepared together with standard procedures for assigning the tasks in an interview situation. These tasks were then assigned to four groups of ten children in individual interviews. An independent sample design was used. Two groups consisted of first graders and the other two of fifth graders. One group at each grade level had received special instruction which had been expected to effect their concepts of heat.

Various techniques for describing the results were developed and illustrated using the data obtained. Among these were the proportion of correct predictions and a score reflecting the distribution of responses over the four types of response listed above. The fifth graders scored significantly higher on both of these measures than did the first graders. There were no significant differences between the two groups at each grade level on these measures.

Criteria for evaluating various aspects of a concept assessment program were developed. The paper reports these criteria and describes specific evaluation procedures for each. The application of this assessment approach to curriculum development and evaluation are also discussed.

GROUP ACHIEVEMENT TESTS DEVELOPED FOR TWO BASIC PROCESSES OF AAAS SCIENCE-A PROCESS APPROACH

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The major purpose of the study was to determine whether science process achievement tests could be developed for administration to groups of primary grade pupils. Six Basic Science Process Tests (BSPT) were constructed as samples of the format proposed. Each BSPT was designed to assess one of the basic science processes taught in Parts A, B, and C of the 1967 edition of Science-A Process Approach (Sci-APA). The test items were projected 35mm color slides with a tape recording which asked questions and controlled slide advancement.

Pilot studies with 320 pupils in kindergarten, and first and second grades in Corvallis and Portland, Oregon during the spring of 1968, contributed to the development of general testing procedures and directions for training pupils to use BSPTs. Preliminary indications of item performance and time requirements were determined from administration of validated items to pupils just completing a year of Sci-APA study at minimum expected grade levels. The sample BSPTs were assembled and synchronized for automatic administrations to students who had studied the 1967 edition of Sci-APA.

Measuring and Classifying BSPTs were administered twice to 850 pupils in first, second and third grade classes in Park Falls, Phillips and Rhinelander, Wisconsin during September, 1968. More than 100 students took each BSPT at the minimum expected grade level and had experience in Sci-APA the previous year. More than 100 other students in the same grades who had no Sci-APA experience took the same BSPTs. The two administrations of each BSPT yielded test-retest score pairs which were correlated for each experience group to give reliability estimates for each BSPT.

The major purpose was to determine whether individual primary grade pupils could be assessed in class-size groups to determine their science process achievements. The administrations of the standardized synchronized BSPTs were accepted as reliable on the basis of test-retest correlations. Thus, it was concluded that successful educational measurement instruments can be constructed to assess science process achievement using this format.

A second question was to determine whether there was a difference in BSPT results between students who had and had not studied Sci-APA for a year. The groups with one year of Sci-APA experience had significantly higher mean scores on three of the six BSPTs than the groups without Sci-APA background. Both of the reliable BSPTs which assess process achievements taught in Part A of Sci-APA produced significantly higher means for Sci-APA pupils.

DEVELOPMENT OF TEST ITEMS RELATED TO SELECTED CONCEPTS WITHIN THE SCHEME THE PARTICLE NATURE OF MATTER

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Madison, Wisconsin

The purpose of this study was to develop test items related to selected concepts from the scheme, the particle nature of matter, that are valid, reliable, and useable with pupils at grade levels two through six.

The test items were of the alternate response single concept type. Five items were developed for each concept and each involved a different but associated natural phenomenon. The concepts were selected by the University of Wisconsin Research and Development Center Science Project staff.

The test items were administered to two groups of students from each of five grade levels, two through six, in one elementary school. One class at each grade level received instruction related to the selected concepts by the regular classroom teacher. Teaching procedures and materials employed in the instructional sequence were developed by the Research and Development Center Science Project staff. The control classes did not receive the instruction. Each of the test items was administered to each class in both groups as a pretest and as a post-test.

Item validity was judged with respect to the following criteria: (1) the item is concerned with the selected concepts (Criterion #1), (2) the proportion of the experimental group choosing the accepted response to each item, when administered as part of a post-test, is greater than 0.50, the level attributable to random guessing (Criterion #2), (3) the proportion of the experimental group choosing the accepted response to each item when administered as part of a posttest is greater than when administered as part of a pretest (Criterion #3), (4) the proportion of the experimental group choosing the accepted response to each item, when administered as part of a post-test, is greater than when administered as part of a post-test to the control group (Criterion #4), and (5) the proportions of the experimental classes choosing the accepted response to each item, when administered as part of a post-test, will increase progressively with grade level (Criterion #5).

Since the degree of difficulty and discriminating power of test items influence their reliability, an item was judged reliable if the following criteria were satisfied when the item was administered as a post-test to the experimental group: (1) the item is of nonextreme difficulty,

$-2\sigma \leq X_{50} \leq +2\sigma$, (Criterion #6), and (2) the item is a strong positive discriminator, $\beta \geq +0.30$, (Criterion #7).

The useability of the items (Criterion #8) was judged on the following: (1) the item can be administered and scored easily, (2) test length within a normal elementary class period, and (3) the reading demands on the students are minimal.

Item response data for the several groups, grade level, and treatment effect (instruction or no instruction) were analyzed to determine the validity, reliability, and useability of the test items. Items that met six of the eight criteria were considered "acceptable" items. In some cases, the spurious performance of one or two classes was the reason for an item failing the criteria. In other cases, when most of the experimental classes experienced a pretest to post-test decrease, it is possible that the instructional sequence was inadequate.

Two items satisfied all eight of the criteria and 104 met six or more of the criteria. The criterion most frequently failed was #5, "grade effect," met by only two items. Each of the other criteria were satisfied by 100 or more of the 125 test items. The test items that failed three or more criteria were considered inadequate.

DEVELOPMENT OF THE SCIENCE CURRICULUM ASSESSMENT SYSTEM (SCAS)

PART ONE: INTRODUCTION AND INTERVIEW PROTOCOLS

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Because we are becoming increasingly aware of the importance of science and early school experiences in science, tremendous effort and financial expenditure are going into curriculum reform in science at the elementary school level. Supported largely by the National Science Foundation, scientists and educators have cooperated during recent years in developing materials and programs for elementary school science teaching. The impact of materials and programs developed by the American Association for the Advancement of Science, Elementary Science Study, Science Curriculum Improvement Study, etc., has not been systematically assessed. Data are not available on the extent to which elementary school science teaching and learning have been altered by these and other recent federally-supported programs.

Although efforts have been made at evaluating the new elementary school science programs, there has been no uniform system available for monitoring changes associated with the implementation of science programs. It is especially unfortunate that we have not contrasted existing programs with new programs in terms of behaviors of children and teachers or in terms of the intellectual development of the children. It is equally unfortunate that we have not contrasted one new program with another.

Many science programs have been evaluated by various means during their development with little or no attention to changes in the classroom behaviors of teachers of the programs and with little attention to the day-to-day classroom behaviors of the children. Little or no program evaluation has been directed toward investigating changes in the child's intellectual development as measured by his interpretation of the physical environment; and this should be the ultimate criterion for determining the value of a science program.

Numerous researchers are applying the techniques of interaction analysis (developed by Flanders and others) to the study of changes in classroom behaviors of teachers and children and countless children are being studied (utilizing adaptations of Piaget's techniques) in an effort to identify logical operations associated with their interpretations of their environments. However, little or no work has been directed toward associating classroom behaviors with the child's interpretation of his environment.

SCAS is a system for monitoring changes (in children and their teachers) associated with the classroom implementation of a variety of science curricula. SCAS combines the interview techniques and theories of Jean Piaget with the techniques of classroom interaction analysis. SCAS provides a system for studying the intellectual development of children, classroom behaviors of children and their teachers, and various elements of the science curriculum.

This paper is intended to describe the overall purposes of SCAS, and to describe in more detail the development and application of "Piaget-type" individual interviews with children. The paper also describes means of training interviewers and the procedures used in the interpretation of data collected by interviewers. It reports and interprets data from over 250 children in grades K-6.

The form of the individual interview employed in SCAS is not identical to the clinical method employed by Piaget. Since SCAS is designed to sample the way in which a child interprets a particular part of his environment, the SCAS interview employs prescribed protocols and is therefore more restricted than the Piaget clinical interview. The twelve SCAS interview protocols are described in detail in the first trial edition (May, 1968) of the Handbook for the Application of the Science Curriculum Assessment System.

DEVELOPMENT OF THE SCIENCE CURRICULUM ASSESSMENT SYSTEM (SCAS)

PART TWO: CLASSROOM OBSERVATIONAL SYSTEMS AND CONCLUSION

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Darrell G. Phillips
University of Iowa
Iowa City, Iowa

Although SCAS may be applied to a science curriculum for a variety of reasons, its development has been primarily for the purpose of identifying relationships among classroom behaviors of the child, classroom behaviors of the teacher, and the child's interpretation of his environment. SCAS provides a means for monitoring changes (in children and their teachers) associated with the classroom implementation of a variety of science curricula.

Whether one is developing a curriculum or attempting to monitor implementation of a well-established curriculum, it is important to collect information from teachers and children in the natural environment of teaching and learning. It is inconceivable that any curriculum should be evaluated or that any curriculum should be developed in the absence of systematic and objective classroom data collection. Systematic collection of data in the classroom has been slow in coming. It is apparent that classroom data collection involving observation of teaching has a much longer history than data collection involving systematic observation of teaching.

This paper describes procedures whereby data from teachers and children may be collected in classrooms. The techniques of interaction analysis (including matrix analysis) are applied to the collection and analysis of these data. The categories applied to the classroom behaviors of teachers and students have been developed specifically for the Science Curriculum Assessment System and constitute the "SCAS Classroom Interaction Categories." The techniques for application of these categories have also been developed specifically for SCAS and constitute the "SCAS Observational Techniques."

SCAS Classroom Interaction Categories place classroom behaviors into two major groups: teacher behaviors and student behaviors. Student behaviors are further categorized into: (1) those behaviors which are related to the lesson and (2) those behaviors which are not related to the lesson. Each of these two categories is subdivided into ten specific student behavior categories.

Teacher behaviors are divided into two major groups: (1) teacher interactions with less than seven children, and (2) teacher interaction with more than six children. These teacher behaviors are each divided into ten categories. One of the ten categories in each subgroup of teacher behaviors

and of student behaviors is reserved for non-codable behaviors. Therefore, by a relatively simple coding system it is possible to code 20 different classroom behaviors of teachers.

A classroom observer who applies SCAS Observational Techniques will at any given time be focusing his attention on one individual in the classroom. Three classroom observers form a team in which one member observes the teacher, and each of the remaining two team members observes six children. Detailed descriptions of SCAS Classroom Interaction Categories and Observational Techniques are found in the Handbook for the Application of the Science Curriculum Assessment System (First Trial Edition, May, 1968).

The Science Curriculum Assessment System has been applied in fifteen classrooms in Atlanta, Georgia, and in twelve classrooms in Tallahassee, Florida. Specific questions related to classroom behaviors of teachers and children can be answered quantitatively. This is made possible by matrix analysis and computation of specific behavior "scores."

From interview data each child is described in terms of his response to specific questions in uniformly administered tests. The extent to which a child has used "logical operation" when confronted with various aspects of his environment can be inferred.

Relationships among variables have been investigated by suitable statistical methods (i.e., analysis of variance, regression techniques, scalograms, etc.). Particular emphasis has been placed on identifying changes in the child's perception of his environment, the child's classroom behaviors, and the teacher's classroom behaviors.

This paper reports and interprets classroom behavioral data from 250 children and 27 teachers in grades K-6.

Session VIIb - Science Instruction in the Junior High School

Chairman: Abraham S. Fischler, Nova University, Fort Lauderdale, Florida.

1. "Determining the Level of Inquiry in Teachers' Questions," George T. Ladd, Boston College, Chestnut Hill, Massachusetts.
2. "A Comparison of Group and Individualized Instructional Techniques in Seventh Grade Science," Robert James, Kansas State University, Manhattan, Kansas.
3. "Logical Thinking in Seventh, Eighth, and Ninth Grade Students," Robert E. Lepper, California State College at Fullerton, Fullerton, California, and Darrell G. Phillips, University of Iowa, Iowa City, Iowa.

DETERMINING THE LEVEL OF INQUIRY IN TEACHERS' QUESTIONS

George T. Ladd*
Boston College
Chestnut Hill, Massachusetts

The main null hypotheses are

(1) There will be no significant agreement between the judges as to the level of inquiry required by each category of the Smith and Meux (1960) question classification scheme.

(2) There will be no significant agreement between the judges as to the appropriateness of the proposed definition of the word inquiry as it is commonly used in the context of a classroom discussion.

(3) There will be no significant effect attributable to the inquiry level of teacher questioning on group achievement on either low or high inquiry post-test questions.

A judge's rating scale was sent to sixteen science educators throughout the United States. The scale was used to (a) classify each category of the classification scheme as the level of inquiry required, (b) assess the appropriateness of the proposed definition of the word inquiry. The results of the rating scale were used by seven experienced secondary science teachers in selecting twenty-five low and twenty-five high inquiry earth science questions for use on the post-test examination.

Audio tape recordings were made of three specific classroom discussions taking place in forty ninth grade earth science classes where an experimental curriculum was being evaluated. To determine the predominant inquiry level of a teacher's questioning behavior transcripts of each tape were prepared and analyzed by the investigator. This analysis was combined with the class mean I.Q. (as measured by the Differential Aptitude Test) and group achievement scores on the low and high portions of the post-test examination for statistical analysis.

The statistical techniques used to evaluate the experimental data included (a) proportions, (b) Scott's reliability coefficient, (c) analysis of covariance with one covariable (I.Q.), and (d) test for homogeneity of regression.

All null hypotheses were rejected with

(1) The judges showing significant agreement on the (a) level of inquiry required by each category of the classification

* Formerly at Indiana University. Bloomington, Indiana.

scheme (88.3 percent), (b) appropriateness of the proposed definition of the word inquiry (93.8 percent).

(2) There being a significant effect attributable to the level of teacher questioning on group achievement on both low and high inquiry questions (beyond the .001 level of confidence).

In recent years the practice of emphasizing only low level questions has been decried because they fail to elicit higher levels of thought and because they give students the impression that science is nothing but a conglomeration of facts. Considerable emphasis has been placed on searching for ways and means of developing teachers' ability to ask high level thought provoking questions, and to maintain this ability once developed. These efforts have not, however, been too successful. The questioning practices of today's teachers is not significantly different than the practices of the teachers studied in the early part of the century. A possible explanation for this failure is that the teachers are not aware of the level of cognition which their questioning can elicit in their student and its relationship to student achievement.

This research provides a refined instrument with which the classroom teacher can directly and accurately measure the level of inquiry of his questions. With this increased awareness the teacher can modify his questioning behavior and thereby change the students conception of science and his performance.

A COMPARISON OF GROUP AND INDIVIDUALIZED INSTRUCTIONAL TECHNIQUES IN SEVENTH GRADE SCIENCE

Robert James
Kansas State University
Manhattan, Kansas

The Intermediate Science Curriculum Study (ISCS) has developed a junior high school science program. An integral part of this program is a set of semiprogramed materials which eliminate group-instructional techniques and thereby make it possible to individualize the instruction. The purpose of this study is to compare outcomes between two classes where one was taught with methods similar to those suggested by ISCS and the other taught by group-instructional techniques.

The seventh grade science course, Matter, at University Schools, University of Iowa, has a rationale similar to that reported for ISCS. Materials prepared were based on the content outline for the Matter course. The two classes of about thirty students each were taught by the same teacher. The content was the same. Hypotheses were stated regarding five areas of student outcomes. These included: achievement of facts and concepts, development of critical thinking skills, understanding of the nature of science, subject preference, and retention of facts and concepts. Three levels of general aptitude were established. Half of each level was randomly assigned to each treatment. This facilitated the use of analysis of covariance within a treatment by levels design. Post-test scores were adjusted on the basis of pretest scores. Retention scores were adjusted on the basis of post-test scores.

The null hypotheses of no significant difference was used at the 0.05 level for achievement and retention of facts and concepts, development of critical thinking skills, subject preference, and understanding of the nature of science. In the understanding of the nature of science, the two treatments differed significantly on only one of five subtests. Though not statistically significant, the adjusted means for the individualized class consistently surpassed those for the group-instructed class in the scores on Read General Science Test; Seventh Grade Matter Final; Watson-Glaser Critical Thinking Appraisal, total score; Test on Understanding Science, total score; Prouse Subject Preference Test; and Silance Attitude Scale.

In a student opinionnaire 80% of the individualized class would elect individualized instruction next year, although nearly half of the lower level students preferred group instruction. About 50% of the individualized class described themselves as easily distracted during class as compared to 70% in the group-instructed class. A larger portion of the individualized class was inclined to think that the social interaction inherent in this class had helped them learn to get along better with their classmates. In making comparisons with other classes, the students in the individualized class were more prone to report that they had solved more

problems, taken more of the responsibility for their learning, and participated more in the class. It is particularly interesting that a number of better students in the individualized class thought they received less teacher-attention and felt less at ease compared to their classes.

In general, this study indicates that the use of these materials results in measured outcomes which do not differ significantly from those of group instruction. Materials of this type may constitute a basic course from which the teacher may digress in an effort to individualize instruction without a loss in measured learning outcomes. Perhaps this is the most significant conclusion suggested by this study.

LOGICAL THINKING IN SEVENTH, EIGHTH, AND NINTH GRADE STUDENTS

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Fullerton, California

Darrell G. Phillips
University of Iowa
Iowa City, Iowa

Five problems from The Growth of Logical Thinking by Inhelder and Piaget, were presented to sixty seventh, eighth, and ninth grade students at Fullerton, California and Iowa City, Iowa. Subjects were selected randomly from participating classrooms, and the data were collected by means of individual interviews with each subject.

The work of Jean Piaget has prompted the performance of numerous research studies. Most of these investigations have concentrated heavily upon various aspects of "conservation" tasks which examine the child's interpretation of certain invariant properties of objects. Since many conservation tasks are concerned with the young child, most of the published investigations have dealt with pre-school and primary grade children. This is all well and good, and there is still need for more carefully controlled research with young children in this area. But very little research has been reported in which Piaget-type problems have been presented to junior or senior high students. In effect, we know very little - in terms of logical thought processes - about how the secondary school student deals with or interprets his environment.

Piaget designates the 11-15 year age range as the time when human beings can begin to deal with propositional logic and can structure new combinations of mental operations. If we accept the tenet that the development of logical thought is a desirable goal in science instruction, then research devoted to various aspects of logical thinking has implications for science curricula and science instruction.

The purpose of this research was twofold: (1) to replicate selected experiments from The Growth of Logical Thinking; and (2) to examine the feasibility of individual interview techniques for collecting data of this type.

Final results and data will be reported.

Session VIIc - Symposium: The Development, Implementation and Analysis of a Programed Approach to the Teaching of Upper Elementary School Science

Chairwoman: Mary Ann MacDougall, University of Virginia, Charlottesville, Virginia.

1. "The Development and Evaluation of Programed Science Materials with Elements of Critical Thinking," William D. Hedges, Chairman, Department of Education, University of Missouri, Columbia, Missouri; Ertle Thompson, Assoc. Professor, University of Virginia, Charlottesville, Virginia.
2. "The Teaching of Upper Elementary School Science Using Programed Materials Coupled with Student Performed Experiments," Jeff A. Pyatte, Assistant Professor of Education, University of West Florida, Pensacola, Florida, and Mary Ann MacDougall, Associate Professor of Education, University of Virginia, Charlottesville, Virginia.
3. "The Relationship Between Achievement in Science and Mode of Experimentation with Respect to Selected Student Characteristics," William S. Donaldson, Research Associate, Bureau of Educational Quality Assessment and Assistant Professor, Center for Cooperative Research with Schools, College of Education, Pennsylvania State University, University Park, Pennsylvania.
4. "Computerized Model for the Management of Materials Development and Individualized Instruction," Milton D. Jacobson and Mary Ann MacDougall, Associate Professors of Education, University of Virginia, Charlottesville, Virginia.
5. "An Automated Analysis of the Structure of Programed Science Materials: Application to BSCS Units," John Moody, Instructor, University of Virginia, Charlottesville, Virginia.

SUMMARY OF SYMPOSIUM

In 1962 the Bureau of Educational Research, University of Virginia, initiated a series of studies to test the efficacy of programed science materials at the upper elementary school level, coupled with an investigation of the influence of the individual student performance of simple science experiments. The symposium papers are an outgrowth of the research which has focused on the following objectives:

1. The development and evaluation under several conditions of a one-year course of study in programed science - William D. Hedges and Mary Ann MacDougall - A Comparison of Three Methods of Teaching Elementary School Science Involving Programed Learning, CRP 1972, August, 1965.

2. The training and instructional procedures which are effective in adapting programed materials to the educational program - Mary Ann MacDougall, The Teaching of Upper Elementary School Science Using Programed Materials Coupled with Student Performed Experiments, CRP 6-1319, August, 1968.

3. Adaptation to the Computer as a research tool to evaluate programing methods and to identify specific structural features of programs - Methods of Presenting Programed Science Materials to Fourth Grade Pupils of Varying Ability, CRP 6-1310, Mary Ann MacDougall and Milton D. Jacobson.

The substantive contribution of each paper is summarized below.

1. "The Development and Evaluation of Programed Science Materials with Elements of Critical Thinking," focuses on the development and evaluation of the instructional effectiveness of the programed approach under several experimental conditions and the influence of the techniques of critical thinking introduced into the materials.

2. "The Teaching of Upper Elementary School Science Using Programed Materials Coupled with Student Performed Experiments," incorporates the program features within an instructional system, in which the training, supervision, and implementation of the programed-centered approach was carried out in twenty-four upper elementary classes.

3. "The Relationship Between Achievement in Science and Mode of Experimentation with Respect to Selected Student Characteristics," reports on an extended study of the implementation of the programed science approach which examines the possibility of using a knowledge of a student's ability and personality adjustment to prescribe a mode of experimentation.

4. "Computerized Model for the Management of Materials Development and Individualized Instruction," proposes further development of a computerized model for managing the development of programed material and for managing individualized instruction. This model incorporates a flexible multivariable (.25) approach to determine both the readability of materials and to guide the writing and developing of computer-assisted instructional materials.

5. "An Automated Analysis of the Structure of Programed Science Materials: Application to BSCS Units." This paper applies the automated analysis to BSCS programed units and identifies from among twenty-five frame, response, content presentation variables, those program features which contribute to a high error rate and low achievement.

Concurrent Sessions VIII

Session VIIIa - Teacher Education in Science

Chairman: Frank X. Sutman, Temple University, Philadelphia, Pennsylvania.

1. "The Relationship Between the Change in Pupil Control Idealogy of Student Teachers and the Student Teacher's Perception of the Cooperating Teacher's Pupil Control Ideology," Richard A. Roberts, Oklahoma State University, Stillwater, Okiahoma, and Jacob W. Blankenship, University of Houston, Houston, Texas.
2. "A Comparison of the Verbal Behaviors of Pre-Service Teachers When Teaching Students and When Teaching Peers," Earl J. Montague, University of Texas, Austin, Texas.
3. "Patterns of Problem-Solving Behavior Among Prospective Science Teachers," R. G. E. Mitias, Ohio University, Athens, Ohio.
4. "A Correlation of Biology Teachers' Pupil Control Ideology and Their Classroom Teaching Practices," Paul L. Jones, Oklahoma State University, Stillwater, Oklahoma, and Jacob W. Blankenship, University of Houston, Houston, Texas.
5. "An Analysis of Selected Factors Promoting Changes in the Role of the Teacher," Paul N. Hovsepian, Detroit, Michigan.

THE RELATIONSHIP BETWEEN THE CHANGE IN PUPIL CONTROL IDEOLOGY OF STUDENT TEACHERS AND THE STUDENT TEACHER'S PERCEPTION OF THE COOPERATING TEACHER'S PUPIL CONTROL IDEOLOGY

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Oklahoma State University
Stillwater, Oklahoma

and

Jacob W. Blankenship
University of Houston
Houston, Texas

Attitudes and beliefs concerning: (1) teaching, and (2) the control of the students to be taught, play a crucial role in determining a science teacher's classroom effectiveness. This is especially true with the increasing emphasis upon student involvement in science classrooms. The interaction of student teacher and cooperating teacher is considered significant in the socialization of student teachers. The purpose of this study is to examine one set of beliefs, the teacher's pupil control ideology, in an effort to determine how this set of beliefs is influenced by the pre-service teacher's interaction with her cooperating teacher during student teaching.

Using a sample of 108 elementary student teachers, the relationship between student teacher change in pupil control ideology and student teacher perception of cooperating teacher pupil control ideology was examined. Change in pupil control ideology was determined by administering the Pupil Control Ideology Form before and after student teaching. The PCI Form is a twenty-item instrument developed at Pennsylvania State University. It is designed to measure a teacher's pupil control ideology relative to a continuum with humanistic and custodial at its extremes. The student teacher's perception of her cooperating teacher's pupil control ideology was measured using the Perceived Pupil Control Ideology Form, a modification of the PCI Form. Socialization pressure, the difference in student teacher pre-test PCI Form score and the perceived pupil control ideology of the cooperating teacher, was introduced as a measure of the degree of agreement between student teacher and cooperating teacher pupil control ideologies.

Data obtained in this study were analyzed using the t test, Kolmogorov-Smirnov two-sample test, single classification analysis of variance, and the Scheffe' test. The PCI Form scores of student teachers, as a group, increased significantly ($p<.01$) during student teaching. Comparison of two groups, student teachers showing no increase in PCI Form scores and an equal number of student teachers showing the largest increase in PCI Form scores, revealed the two groups to be significantly different on (1) mean Perceived PCI scores ($p<.05$), and (2) mean socialization pressure ($p<.01$). Examination of the differences in mean change in pupil control ideology of student teachers in situations of low, medium,

and high socialization pressure showed the following: the differences in mean change in pupil control ideology for low and medium socialization pressure and for low and high socialization pressure were significant ($p < .01$). The differences in mean change in pupil control ideology for medium and high socialization pressure were not significant.

A COMPARISON OF THE VERBAL BEHAVIORS OF PRE-SERVICE TEACHERS WHEN TEACHING STUDENTS AND WHEN TEACHING PEERS

Earl J. Montague
The University of Texas
Austin, Texas

With the advent of videotape feedback as an integral part of the science methods course at The University of Texas at Austin a question arose concerning the comparability of teaching behaviors exhibited by methods students when role playing with peers and when teaching high school students in the classroom. The problem broadly considered was, "In what ways is role playing with peers a valid reflection of the verbal behavior which would be exhibited when teaching secondary school science students?"

It seemed reasonable that the teaching behavior exhibited when teaching peers would be different than that exhibited when teaching students in a high school science classroom. The validity and usefulness of videotape for evaluation and feedback is limited to the degree teaching behaviors in the two situations are comparable. This study attempted to identify those behaviors which may be comparable in the two situations.

Nine students were enrolled in both student teaching and a secondary science methods course. Each student planned a 20 minute teaching sequence to introduce new content by means of a demonstration. The demonstration and its use were to be designed to not only introduce some new content but also to provide the students with some experience using one or more inquiry skills. The student teachers were videotaped while teaching this lesson to a group of approximately 16 peers. They were then audiotaped while teaching the same lesson to a high school science class. The instrument used to analyze the varbal behavior was Flanders' Ten Category Interaction Analysis. The Scott coefficient measuring coder agreement between three coders was 0.879. The t test in conjunction with a correlation coefficient was then used to detect any patterns associated with individual and group verbal behavior, as well as the significance of any differences between the two situations.

No significance difference in group means was found in the following verbal behaviors: (1) the percent of time devoted to praising, using student ideas, lecturing, and giving directions; (2) the percent of student talk, both solicited and unsolicited; (3) the I/D ratio; and (4) time devoted to extended lecture.

Significant differences at the 0.10 level were found in the following behaviors: (1) the teachers spent more time talking when teaching peers; (2) the I/D ratio was higher when teaching peers. When teaching peers the teachers asked more and longer questions with the differences being significant at the .05 and .01 levels respectively. No criticism was used when teaching peers while 0.55% of the time was devoted to criticism when teaching high school students.

The I/D ratio and the amount of lecturing time for individual teachers were very stable. Individuals changed from one situation to the other in almost all of the Flander's categories, but with few clear patterns. The magnitude of these changes appear to be equivalent to those one might expect to find when a teacher teaches any two classes. This hypothesis will be investigated in subsequent studies.

The verbal behavior exhibited by pre-service teachers when teaching peers is comparable in many respects to that behavior exhibited when teaching secondary school science students. When the difficulties of obtaining secondary school students for use with methods classes is compared with the dissimilarities identified when teaching peers rather than secondary students, it is the author's opinion that role-playing with peers is a reasonable and effective substitute.

(This study has been replicated, and these results will be available for presentation at the convention.)

PATTERNS OF PROBLEM-SOLVING BEHAVIOR

AMONG PROSPECTIVE SCIENCE TEACHERS

by

R. G. E. Mitias
Ohio University
Athens, Ohio

Careful study of the literature showed an apparent conflict between Dewey's point of view and that of experimental and empirical psychologists regarding problem-solving processes. Most of the samples used by psychologists, however, showed a high degree of heterogenity, and apparent effects of certain experimental conditions. Thus, the purpose of this study was to empirically investigate how a fairly homogeneous sample of prospective science teachers solve problems under a minimum of experimental conditions; and if the subjects behavior was related to (1) the major science field of the subjects, and (2) type of problem to be solved.

The study was designed to test four hypotheses:

1. There are several patterns of problem-solving behavior, for a given problem, within this sample

2. Patterns of problem-solving behavior differ for the same experimental unit from one problem to the other

3. The difference in patterns in solving a given problem is less observable between units which have the same academic major than between units which have different academic majors

4. The difference in patterns among the three subsamples is statistically significant at the accepted 0.05 level.

Each two subjects worked together as an experimental unit to solve two problems: the Cylinder Problem and the Disc Transfer Problem*. The sample included experimental units majoring in biological sciences, comprehensive sciences, and physical sciences. All subjects were college seniors within a given range of age, OSPE score, and number of credit hours in their respective majors.

Prior to collecting experimental data, a six-category observational system was developed (goal clarification, situation analysis, procedure planning, procedure execution, random manipulation, and irrelevant behavior). A trial run was conducted to standardize the problem-situations, recording instrument, time unit, and observer's responses. The experimental data were analyzed in terms of (a) sequence of categories

* These problems are frequently mentioned and widely used in psychological research on problem-solving.

of behavior, (b) frequency of each category, and (c) number of categories.

Graphical analysis of the data showed that four patterns of problem solving processes were identified regarding the sequence dimension. There were also apparent variations in both the frequency and number dimensions*. Thus, the first hypothesis was established. Changing from the Cylinder to the Disc Problem presented different patterns of problem-solving processes by the same experimental units. Thus, the second hypothesis was also established. The data indicated that the third hypothesis could not be established since the difference among units of subsamples was not more observable than the difference within a given subsample.

Statistical analysis of the data** showed that the difference among the three subsamples was not significant at the 0.05 level. Thus, the fourth hypothesis could not be established.

This study was originally planned to help in solving a philosophical-empirical conflict regarding the dominance of a universal pattern of problem-solving behavior (Dewey's). The results of this study seem to shed some light on this conflict. It was also possible to establish a relationship between patterns of problem solving behavior and the type of problem solved. A major significant outcome of the study was, however, the development of a direct and easy to use method of observing and categorizing problem-solving behaviors in order to identify the mental processes involved. This development became necessary, when a thorough review of the literature revealed the absence of a usable and comprehensive instrument.

Problem-solving behavior has been emphasized as a major objective of science teaching. Using the observational instrument of classifying behavior - as developed here - could help educators assess the impact of a given methods course or courses on developing certain patterns of behavior, modifying these, or changing them. Thus, a broad area of research in learning and curriculum development could be systematically and empirically investigated.

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* Slides and transparencies are available and could be used in presenting this paper.

** Kendall's coefficient of concordance W, conditional transitional probabilities, and an analysis of variance design were used.

A CORRELATION OF BIOLOGY TEACHERS' PUPIL CONTROL IDEOLOGY AND THEIR CLASSROOM TEACHING PRACTICES

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and

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Classroom teaching practices that stress active student involvement in classroom experiments and discussions are being advocated in the literature and in curriculum innovations, such as BSCS Biology. Willower has indicated that teachers will tend to resist innovative changes in the school program because they are concerned with pupil control. This study examines the correlation between biology teachers' pupil control ideology and their classroom teaching practices.

Using a sample of 68 high school biology teachers, selected by a stratified randomized process, the relationship between the teachers' pupil control ideology and their classroom teaching practices was examined. The pupil control ideology of the teachers was measured using the Pupil Control Ideology Form (PCI Form), developed at Pennsylvania State University. The PCI Form is a twenty-item instrument designed to measure a teacher's pupil control ideology relative to a continuum with humanistic and custodial at its extremes. The biology teachers' classroom teaching practices were measured using 2,040 completed copies of the Biology Classroom Activity Checklist (BCAC) developed by Kochendorfer and Lee at The University of Texas. The Biology Classroom Activity Checklist is a fifty-three item student report instrument that measures the extent to which classroom practices recommended by BSCS are employed by the teacher in the classroom.

A Pearson product-moment correlation coefficient was calculated between the teacher's pupil control ideology score and the class mean scores on the BCAC. The correlation coefficient was significant (p .01). Correlation coefficients were also calculated between the teacher's pupil control ideology score and the four subscores on the BCAC that measures teaching practices where the teacher plays a major role in the teacher-pupil interaction. The correlation coefficients calculated were significant (p .05).

Curriculum projects that have as a major focus innovative changes that stress active student involvement in classroom experiments and discussions should be aware of the tendency on the part of "custodial" teachers to resist such changes because of concern with control of students. If further studies confirm these findings, teacher training programs should include activities that would tend to lessen the teachers' concern in this area of rigid control of students.

AN ANALYSIS OF SELECTED FACTORS PROMOTING CHANGES IN THE ROLE OF THE TEACHER

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A major problem in the adoption of a curriculum modification such as the Biological Sciences Curriculum Study - BSCS Molecules to Man (Blue Version) - is changing the role of the teacher in the complex teacher-student relationship.

This study was designed to ascertain the correlations of selected factors with the role of the biology teacher in the implementation of the BSCS Molecules to Man (Blue Version) program in the Detroit public senior high schools. These factors include:

1. Teacher's attitude toward the BSCS rationale.
2. Teacher's recency of undergraduate education.
3. Teacher's participation in Board of Education Workshops.
4. Teacher's participation in BSCS Summer Institutes.
5. Teacher's participation in NSF Summer Institutes.
6. Teacher's participation NSF In-Service Institutes.
7. Availability of laboratory facilities.
8. Availability of instructional supplies.

In order to correlate the eight selected factors with the teacher role it was necessary in the study to determine the nature of the teacher's classroom activities. This would reflect the degree to which the teacher's role conformed to the approach advocated by BSCS. The Biology Classroom Activity Checklist (BCAC) developed by Kochendorfer and Lee was utilized for this purpose. [1]

[1] Leonard H. Kochendorfer, "A Comparative Study of the Classroom Practices and Teaching Rationale of High School Biology Teachers Using Different Curriculum Materials," Unpublished Doctoral Dissertation, University of Texas, 1966.

The Blankenship Teacher Attitude Inventory was administered to determine the extent to which the teacher agreed with the BSCS rationale.[2]

A teacher questionnaire was also administered with the Teacher Attitude Inventory to ascertain information relative to factors two through eight (ie., recency of undergraduate training, participation in Board of Election Workshops, etc.).

The sources of data for this investigation included: files and records of the Mathematics and Science Education Department of the Detroit Public School System; seventy biology teachers in the Detroit system with at least two years of teaching experience with BSCS Molecules to Man (Blue Version) and their students.

Analysis of the data revealed that there were correlations between the teacher's attitude toward the BSCS rationale, the teacher's participation in BSCS Summer Institutes, the teacher's participation in NSF In-Service Institutes and the role of the teacher in the classroom as detected by Biology Classroom Activity Checklist.

It is clear from this study that the implementation of a program requiring a change in the teacher's role is significantly related to certain factors. One can expect curriculum change when teachers' attitudes towards the subject matter are changed and when the way in which they relate to their students is changed.

One cannot expect attitudes to be changed substantially on a limited crash program of in-service education. Intensive in-service programs, such as a six or eight week summer institute, are necessary to allow the teacher adequate time for direct involvement with the new material in order to understand the rationale and philosophy of a new program. This should suggest to school systems the necessity of budgeting adequate funds to support intensive in-service teacher education programs. An alternative is to implement co-operative college-school science programs such as those funded by the National Science Foundation.

This study should suggest to the science supervisor the need to promote teacher participation in summer institutes which are directly related to the programs that they wish to implement.

Relative to pre-service education, this study suggests the need to help the future teacher identify and understand the importance of his role in the classroom and its ultimate effect upon student behavior.

The new science curricula have been developed in such a way that a change in the role of the teacher is a pre-requisite to the success of the programs. It would seem research is needed into the role of the biology teacher in the implementation of the BSCS program.

[2] Blankenship, J. S., "An Analysis of Certain Characteristics of Biology Teachers in Relations to their Reactions to the BSCS Biology Program," Unpublished Doctoral Dissertation, University of Texas, 1966.

School systems which adopt programs on a system-wide basis need to know the kinds of changes in teacher behavior which will be required to insure their success. It is therefore critical to determine which factors in the changing role of the teacher are most significant and by which methods these changes can be achieved. For example, how effective is it to implement the adoption of a new program into a school system by utilizing an in-service training program sponsored by school district or NSF funds? Should school systems urge their teachers to participate in NSF Summer Institutes specifically designed for a newly adopted program to help insure its success? Does the factor of teacher age hinder the change process in the role of the teacher?

It is clearly recognized that the teacher is the key to the success of any program. It appears expedient to investigate the factors which affect teacher behavior in the implementation of a program.

Apart from status studies, there is little research that describes the behavior of the science teacher in the classroom. The information gained from this study may give insight to school systems into the problems of implementation they must recognize when adopting a modified curriculum. It may also hold implications to the designers of curricula in terms of the planning for teacher training programs.

Session VIIIb - Teacher Education in Elementary School Science

Chairman: Addison E. Lee, University of Texas, Austin, Texas.

1. "A Study of Verbal Behavior Patterns in Primary Grade Classrooms During Science Activities," Thomas Charles Moon, California State College, California, Pennsylvania.
2. "Evaluation of the Colorado Elementary Science Project," Jerry G. Horn and Ronald D. Anderson, University of Colorado, Boulder, Colorado.
3. "A Leadership Workshop on Elementary School Science: An In-Depth Evaluation," Dale G. Merkle, Shippensburg State College, Shippensburg, Pennsylvania.
4. "Assessment of the AAAS Science-A Process Approach Institute - A Cooperative College - School Science Project," William S. LaShier, Jr., Kansas State Teachers College, Emporia, Kansas.
5. "Evaluation of an Approach to Graduate-Level Science Education for Elementary School Teachers," Kenneth F. Jerkins, Morgan State College, Baltimore, Maryland.
6. "A Comparison of the Effects of Two Structures of Knowledge on the Application of Science Concepts by Preservice Elementary School Teachers," Lee A. Dallas, Western Washington State College, Bellingham, Washington.
7. "Pre-Service Methods and the 'New' Elementary Science Curricula," Richard N. Avdul, Ohio University, Athens, Ohio.

A STUDY OF VERBAL BEHAVIOR PATTERNS IN PRIMARY GRADE CLASSROOMS DURING SCIENCE ACTIVITIES

Thomas Charles Moon
California State College
California, Pennsylvania

This study was designed to analyze selected examples of verbal behavior patterns in primary grade classrooms during science activities. Thirty-two elementary school teachers within five mid-Michigan public school districts comprised the population under consideration. Sixteen of these teachers taught science in the manner suggested by their respective school districts. Each of the sixteen remaining teaching participants within the experimental population received an in-depth study of the Science Curriculum Improvement Study's teaching methods and materials in a three week workshop during the summer of 1968. This study was designed as a quasi-experimental, time-series analysis and involved a series of science teaching observations that began in April, 1968, and were concluded in March, 1969.

Each science lesson was recorded with easily portable, battery powered tape recorders, and two of the three instruments used in evaluating the study's data were exclusively concerned with information gathered from analyses of the taped lessons. These two instruments were the Flanders System of Interaction Analysis and the Science Teaching Observational Instrument. The third instrument, the Science Process Test for Elementary School Teachers, centered upon an evaluation of teachers' process skills and comprehension of selected science concepts. Statistical treatments used were a repeated measures design of a mixed model analysis of variance, the Friedman two-way analysis of variance by ranks, and t tests for correlated data.

The following are among those findings obtained through analyses of the collected data:

1. those teachers who were exposed to the teaching methods and materials suggested by the Science Curriculum Improvement Study differed significantly from those teachers employing conventional science teaching methods and materials, by demonstrating an increase in the amount of direct teacher influence displayed in verbal behavior patterns during science activities. Apparently this was due to an increased percentage of teacher direction-giving to young children who were actively involved with science materials;

2. there was a pronounced shift in the question preferences displayed by the experimental teachers after the introduction of SCIS teaching methods and materials. The original observations demonstrated a heavy reliance upon low order question types.

After the workshop's conclusion, the teachers demonstrated a much greater preference for higher level questions; and

3. although the SCIS summer workshop's activities seemed to have a definite influence upon the experimental teachers' science presentations during those fall months immediately following its conclusion, the types of science materials used by these teachers also might have contributed to this influence.

Results from data analysis demonstrated that the SCIS teachers used fewer low order questions and a greater percentage of high order questions immediately after the summer workshop. Yet as the school year progressed, the teachers' preferences for question types began to closely parallel their question patterns demonstrated during those months before participation in the summer workshop. Possibly more effort should be placed upon continual supervision and in-service consultation throughout the school year in future implementation projects, in an effort to sustain any gains made during a summer workshop experience.

Some SCIS teachers seemed to expend an unreasonable amount of class time in the distribution and retrieval of science materials. It appears that such elementary school teachers could benefit from systematic instruction in the handling and distribution of science equipment.

A STUDY OF CHANGES IN TEACHING STYLE AMONG TEACHERS IN A CURRICULUM IMPLEMENTATION PROGRAM

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The purpose of the study was to (1) evaluate changes in teaching style resulting from an inservice education program designed to aid teachers in the implementation of the AAAS or ESS elementary school science program and (2) determine correlates of particular styles of teaching.

All subjects were members of one semester inservice education classes which were taught by fellow elementary school teachers who had participated in a year long program designed to aid them in the adoption of a new science program (AAAS or ESS) and to prepare them to teach other teachers. From among approximately 150 teachers, 28 were randomly selected for a pretest measure and another 28 were randomly selected for a post-test measure. This design, $\begin{matrix} R & O & X & \\ R & & X & O \end{matrix}$, reduced problems of invalidity due to factors such as the testing effect and the interaction of testing and the treatment. The measure of teaching style was a rating on an observation scale designed to measure both verbal and non-verbal interactions among teacher, students and materials. The ratings were based on video-tape recordings made in each teacher's own classroom while using curricular materials written specifically for purposes of the evaluation. Scores on a semantic differential instrument, the Rokeach dogmatism scale, a standardized science achievement test, and the Wisconsin Inventory of Science Processes were obtained and their correlation with teaching style determined.

Differences in teaching style between the pre and post groups were found to be significant at the .01 level. Correlates of teaching style are reported. The study provides evidence that inservice education and assistance in the implementation of new curricular programs, which will result in significant changes in teaching styles, can be provided on a large scale basis through teaching teachers to teach other teachers.

A LEADERSHIP WORKSHOP ON ELEMENTARY SCHOOL SCIENCE: AN IN-DEPTH EVALUATION*

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New elementary school science curricula are emerging rapidly today. The Michigan State University Leadership Workshop on Elementary School Science was designed to instruct college teachers and school consultants in two of these new curricula: the Science-A Process Approach (AAAS) and Science Curriculum Improvement Study (SCIS).

This Workshop, held at Michigan State University in the summer of 1968, had as one of its objectives the influencing of the participants to promote these curricula and initiate change. It was unique in structure in that it incorporated into the format of the Workshop not just orientation to the programs, but also training in group-process skills, change-agent skills, and a participant-operated workshop which established initial contact for the participants with school systems in their areas.

This study was designed to evaluate the reactions of the participants to the activities of the Workshop and to interpret the effect these activities have on the behavior of the participants after they leave the Workshop.

Pre-Workshop, post-Workshop, and follow-up midwinter conference measures were made on: Knowledge of the two elementary science curricula, knowledge of group-process skills, knowledge of change-agent skills, and attitudes of the participants toward the two new curricula. An assessment was also made of the participants' perceived needs (pretest) and satisfied needs (post-test). Other attitudes were measured also.

Statistical tests were made of the data to determine if meaningful learning took place and to identify correlations between the measures.

Significant differences in knowledge of the two programs, knowledge of group-process skills, knowledge of change-agent skills, and in attitudes toward the two elementary science curricula were found. Investigations of the correlations between measures were made to determine if significant positive relationships between attitude and knowledge, or attitude and satisfaction of needs existed. No significant correlations were discovered with total group comparisons.

When the participants returned to Michigan State University in December 1968 for the follow-up conference, instruments were administered to evaluate both the content of the Workshop and how the participants utilized the Summer Workshop experience.

* From a study done at Michigan State University under the guidance of Dr. T. Wayne Taylor, with the cooperation of the National Science Foundation Workshop director, Dr. Richard J. McLeod.

Meaningful changes in the behaviors of the participants were noted. Increased in-service activities and an altering of pre-service courses to include more of the AAAS and SCIS philosophies and activities were among the changes reported. The results of this study seem to indicate that workshops can be an effective instrument for producing desired behavioral changes.

ASSESSMENT OF THE AAAS SCIENCE-A PROCESS APPROACH INSTITUTE - A COOPERATIVE COLLEGE-SCHOOL SCIENCE PROJECT

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The goal of the summer phase of the NSF - CCSS project was to conduct a five week institute for 35 elementary school teachers and administrators interested in subsequently implementing the AAAS Science-A Process Approach materials into the first and second grades of their schools.

Prior to the institute, interaction analysis data were gathered while observing 18 of the teachers teaching a science lesson of their own choice. The composite matrix indicated that someone was talking approximately 80 percent of the time, approximately 67 percent of the time it was the teacher talking and roughly 50 percent of the teacher talk was classified as direct influence.

The format of the institute included the activities in the AAAS Guide for Inservice Instruction. In addition, a series of 11 experimental stations were set up the final week and the participants worked on these experiments which required a synthesis of the individual process skills which had been previously developed. In the afternoons the participants observed and worked with four classes of first and second grade students.

Pre- and post-measure scores on the Science Process Measure for Teachers indicated that prior to instruction the participants had a mean score of 11.40 out of a possible score of 25. After instruction, the group mean was 20.86. Mean sub-scores on nine areas provided information as to science competencies which would require additional attention during the academic phase of the project.

Two testing instruments were developed to provide the participants with data as to the process skills already possessed by 137 students entering either the first or second grades within the 13 school districts of the Flint Hills Association. The Set of Competency Tasks, Part B, consisted of 111 tasks selected from existing competency measures associated with 34 exercises in Parts A and B. The Set of Competency Tasks, Part C, consisted of 105 competency tasks representing 24 exercises from Parts B and C. Each of the two instruments would have required 1½ hours to administer. The decision was to use only half the test with a particular child. The test results collected by the teachers were analyzed in terms of where one might begin teaching a particular process, such as measuring. These two instruments are presently being used by the staff to gather additional data on both experimental and control groups for comparison with data to be collected in the spring.

The assessment of the Institute seemed to indicate that teacher competence in science could be significantly improved. Participant observations followed by classroom teaching and then one-to-one teaching appeared to be a valuable aspect of the program. Provision for the participants to spend two days testing in their own schools seemed to clarify, for the teachers, the hierarchial sequences of the AAAS material. The use of videotaped sessions provided additional opportunities to discuss what the teachers might do differently in their own classrooms.

EVALUATION OF AN APPROACH TO GRADUATE LEVEL SCIENCE EDUCATION FOR ELEMENTARY SCHOOL TEACHERS

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A great number of science educators have stated that the colleges and universities are not training elementary teachers to teach sciences properly and that the science background of most elementary teachers is dreadfully low. Some science educators have urged that some way be provided so that graduate credit can be earned in specially designed science courses for those with degrees in areas such as elementary education. As more and more school systems adopt new elementary science curriculum project courses and as more and more school systems make it mandatory that classroom teachers earn a master's degree within a specified time interval there will be an increasing demand for graduate level science education courses emphasizing "structure and content," laboratory activities, the processes of science, and the "spirit" of science as opposed to courses that are best classified as "read-about talk-about courses" with little or no laboratory experiences.

This paper presents a brief overview (through a series of color slides) of what takes place in "Science in the Elementary School," Science 503, an imaginative approach to graduate science education. Science 503 is a required course in the program of study leading to the M. S. degree in elementary education at Morgan State College (Baltimore). The course is both laboratory-oriented and content centered.

Each student, generally an in-service elementary school teacher having more than five years of teaching experience, works in a small team or group of 3-5 persons.

Laboratory activities and group presentations are principal features of the course. Nevertheless, "how" Science 503 is taught is the most significant feature of the course. The classes are very informal. There are relatively few formal lectures. Discussions are directly related to some laboratory activity. The instructor seldom abandons the role of "guide and prompter." Students are urged continuously to "observe, report, and explain or interpret." At the outset of the course the students are told that "devious" methods will be used to create situations in which groups can demonstrate good problem solving techniques and utilize the "processes of science."

The principal focus of this paper is the presentation and interpretation of questionnaire data obtained from one-hundred students who were enrolled in Science 503, "Science in the Elementary School," at Morgan State College (Baltimore) during the period January 1966, - May, 1969.

The questionnaire designed for the survey included 80 structured items organized in clusters relating to course objectives, course content, methods and procedure, and probably outcomes of the course. Also, five

open items were used to elicit suggestions, criticisms, and general comments.

Computerized data processing techniques were used to tabulate, organize, and analyze questionnaire data obtained through the 80 structured items. The Kolmogorov-Smirnov one-sample test and other non-parametric statistical tests were used to determine the extent to which questionnaire responses indicated significant, positive or negative feelings about various aspects of the course. Also, the data were organized for comparative analysis of responses from various groups completing Science 503 during the period January, 1966 - May, 1969. Some strengths and weaknesses of the course have been identified. Very helpful and encouraging suggestions, criticisms, and comments were obtained through the five open items on the questionnaire.

Overall, it appears that most of the students have markedly positive feelings about most aspects of this approach to graduate-level science education for elementary school teachers.

A COMPARISON OF THE EFFECTS OF TWO STRUCTURES OF KNOWLEDGE ON THE APPLICATION OF SCIENCE CONCEPTS BY PRESERVICE ELEMENTARY SCHOOL TEACHERS

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The primary purpose of the study was to determine what effects the organization or structure of a science curriculum would have on the students' ability to apply the concepts comprising that curriculum. A second aspect involved the correlation of *ex post facto* variables with post-test measures of science concept application.

The science concepts presented were, in the author's opinion, subsumed under a single conceptual scheme of science as proposed by the National Science Teachers' Association curriculum committee in 1964. The Test of Concept Application was developed for use in the study. It was designed to measure behaviors of application as defined by Bloom (1956). The sample comprised 101 preservice elementary school teachers enrolled in the College of Education of Temple University in February, 1967. The equivalence of the experimental and control groups was determined by computing t tests to determine the significance of the difference of mean scores on the following measures: (1) the Scholastic Aptitude Test - verbal subscore, (2) the Scholastic Aptitude Test - mathematical subscore, (3) the students' cumulative point-hour ratio at the beginning of the study and (4) pretest scores on the Test of Concept Application. No significant differences were found between any pair of measures.

Each of the experimental groups took part in a science curriculum comprised of the same ten science concepts taught by the author using the same procedures and materials, but varied in the sequential order or structure. One experimental group was exposed to a hierarchical sequence of concepts and the second was taught in a non-hierarchical order. The control group took part in neither the hierarchical nor non-hierarchical curriculum.

The Test of Concept Application was administered as a power test to each group before the study and again, as a post-test. Again t tests were computed to determine the significance of the difference between pretest-post-test mean difference scores of each of the groups.

Pearson product-moment correlation coefficients were computed between the behaviors of application as expressed by the Test of Concept Application post-test scores and the following *ex post facto* variables:

1. Verbal aptitude as measured by the Scholastic Aptitude Test.

2. Mathematical aptitude as measured by the Scholastic Aptitude Test.

3. Background in science.

4. Performance in college as determined by the cumulative point-hour ratio.

5. The college background of the students' parents.

6. Level of dogmatism as measured by the D-Scale Opinionnaire.

No significant differences were found between paired mean difference scores -- gains -- of the experimental groups. The significance of the difference between mean difference scores -- gains -- of each of the experimental groups and gains of the control group was computed at the .001 level and was considered highly significant. The experimental group showed the greater gains. No significant correlations were found between any pair of measures of *ex post facto* variables and Test of Concept Application posttest scores.

1. The subjects' behaviors of application as defined by Bloom (1956) and as measured by the Test of Concept Application were not affected by the structure of knowledge of the curriculum which they had been taught.

2. The techniques practiced in teaching both the hierarchically and non-hierarchically structured science concepts were effective in increasing the students' ability to apply science concepts.

3. Behaviors of application were not affected by the students' (1) mathematical or verbal aptitude, (2) science background, (3) performance in college, (4) level of dogmatism or (5) the college background of the students' parents.

This study has demonstrated that the structure of closely related concepts is <u>not</u> imperative to the formation of individual cognitive structures. The author's recommendation is that research be designed to examine the expanded role of conceptual schemes in structuring teacher education science curricula. Secondly, the importance of structure of knowledge as related to cognitive theory outside the domain of science education should be further scrutinized.

PRE-SERVICE METHODS AND THE "NEW" ELEMENTARY SCIENCE CURRICULA

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The major problem in this research is to determine the status of the teaching of the "new" elementary science programs at the pre-service level by university educators of Ohio, Kentucky, Pennsylvania, and West Virginia.

This study was undertaken to provide a new stimulus into the responsibility involved for those concerned with teacher preparation. Ways and means must be found whereby all teachers will become familiar with contemporary content, methods, and techniques before they assume their first teaching assignment.

It is anticipated that this study will bring a new awareness of the responsibility of other agencies concerned with the preparation of science teachers and with their improvement. Assisting teachers in a continuing education is a mutual responsibility shared by local school districts, state departments of education and professional organizations.

It is also anticipated that this study will result in a "status quo" survey of current practices in science education methods instruction in Ohio to provide a basis by which comparisons and contrasts may be drawn between those institutions reported in the study and those practiced in any given institution. Furthermore, since the Ohio State Department of Education reports that the greatest number of teachers from out of state come from Kentucky, Pennsylvania, and West Virginia respectively, it is felt appropriate to investigate the extent to which professional courses in those states are exerting influences on the instructional programs in Ohio.

Finally, inasmuch as skills of abstract thinking, nonverbal communication, and motor-orientation characterize the new science programs, experience to date seems to indicate that they do provide a way of meeting some of the differences in children's achievement, including the disadvantaged. Thus, the relevancy of this study to Appalachia becomes significant because Ohio, Kencucky, Pennsylvania, and West Virginia are considered a part of that region, and it becomes increasingly important to determine if individuals concerned with teacher education are cognizant of the role the new sciences can contribute to meeting the needs of rural disadvantaged youth.

To help guide the study, the following hypotheses were stated:

1. No significant difference will exist between Ohio and Kentucky, Pennsylvania, and West Virginia university instructors' attitudes concerning the "new" elementary science programs.

2. No significant difference will exist between academic rank and department affiliation in university instructors' attitudes toward the "new" elementary science programs.

3. No significant difference will exist between types and size of methods courses and university instructors' attitudes toward the "new" elementary science programs.

The questions to be answered are:

1. To what extent are the "new" elementary science curricula being taught in the schools within the stated limitations?

2. What factors are associated with the teaching of the "new" elementary science programs?

3. What factors are associated with the degrees of emphasis on the teaching of the "new" elementary science programs?

The data for this study was acquired through a survey of all four states involved offering methods classes in elementary science. There were approximately 190 educators in the sample population.

A questionnaire was designed and revised by five university professors--one of whom is a science educator. The instrument was mailed to the 190 educators. Due to inadequate returns, a follow-up mailing was required. A total of 133 completed questionnaires have been returned, or 70% of the original total.

The statistical analysis of the data involves non-parametric statistics. Computations are being done through the use of the chi square test.

The following limitations have been recognized in this study:

1. This study is limited by its use of the instrument, which by its very nature precludes total objectivity and is at the same time subject to the possibility of non-response.

2. The population is limited to elementary science methods instructors from teacher training institutions of Ohio, Kentucky, Pennsylvania, and West Virginia. Generalizations of the results of this study to other populations in other geographical areas will necessarily be limited.

3. This study included reference to only twelve of the new elementary science programs.

Session VIIIc - Symposium: Earth Science Curriculum Project Research

Chairman: Robert E. Samples, Earth Science Curriculum Project, Boulder, Colorado

Participants: William D. Romey, Earth Science Curriculum Project, Boulder, Colorado.

Marjorie H. Gardner, University of Maryland, College Park, Maryland.

Larry A. Irwin, Earth Science Curriculum Project, Boulder, Colorado.

John F. Thompson, Earth Science Curriculum Project, Boulder, Colorado.

Daniel J. Bauman, University of Colorado, Boulder, Colorado.

ESCP SUPERCEDED: EMERGENCE OF A NEW IDENTITY

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From 1963 until 1967 the Earth Science Curriculum Project (ESCP) was involved primarily in the production and testing of curriculum materials in earth sciences for the ninth grade level. Production of ancillary materials (films, pamphlets, and newsletters) continues. A shift in emphasis of the project began in 1968 when "curriculum" was redefined in the minds of the project staff to mean "a set of ideas and goals," as opposed to the original definition, "a set of materials." Many different sets of materials, if used in appropriate ways, can help meet the goals of ESCP.

Three new major efforts related to the implementation and installation of the ESCP curriculum (as redefined) are progressing under the sponsorship of the American Geological Institute. A newly evolving Center for Earth Science Education will coordinate these efforts and replace ESCP.

The first of these is an Earth Science Teacher Preparation Program which will attempt to stimulate and provide support for a network of self-sustaining regional centers for earth science education. (Several centers of this type have already begun to develop.) Among the targets for these centers will be programs for in-service and pre-service training of teachers, training of college consultants and resource people, and the production of training materials designed to help teachers and teacher trainers enter creatively into the process of producing teaching materials compatible with the ESCP curriculum.

The second major effort is an Environmental Sciences Project in which new curriculum materials and teaching styles will be developed for use in helping academically unsuccessful students, especially those in inner-city environments. These materials and teaching styles require special efforts to establish an attitude of trust, mutual respect, and openness between teachers and their students. Ambiguous assignments by the teacher lead to the richness of divergent goals set by students themselves and ultimately lead to learning that is relevant, since the need for it has originated within the students rather than being externally imposed.

The third major program is to help coordinate research in earth sciences education, using the resources of ERIC and other such organizations to identify research completed and in progress, to suggest new avenues of research interest, to offer services in evaluation of research proposals for interested parties, and to perform limited research in certain key areas where no other organizations or individuals happen to be working.

The Center for Earth Science Education will hope to include other programs in earth science education as they become desirable.

TOWARD THE INTRINSIC: AN ALTERNATIVE TO COERCION BY INSTRUCTIONAL OBJECTIVES

Robert E. Samples
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The results of specific generations of research have influenced curriculum makers and teachers in such a fashion that educational objectives have evolved. The evolution of the educational objectives are naturally parallel to the evolving patterns of research. The current generation of instructional objectives are borne primarily of cognitive research. Though efforts have been made to state objectives in the affective domain, little success has so far been met. Affective objectives are still muddled because most evaluative efforts in affective research are highly obtrusive and tend to disturb the very quality that is to be measured.

It is the purpose of this paper to offer a substitute premise in which assumptions are substituted for objectives in the evaluative process. Instead of being concerned with cognitive and affective, this premise considers intrinsic versus extrinsic. In doing so it is found that it is not at all necessary to separate the cognitive and affective.

The introduction of the terms intrinsic and extrinsic is not intended to further confuse instructional pedagese. Instead it is intended to emphasize the position that all objectives as currently being written in any of the courses of instruction that currently prevail are extrinsic in quality.

With more and more emphasis being placed on the humanization of education, serious consideration must be given to the quality of education and instruction that is more intrinsic. With this in mind, it seems that the instructional environment should not be created within a matrix of extrinsic objectives as currently is the practice. Instead the instructional environment should be sculptured from what actually takes place in classrooms. The teacher's role would be guided by a series of general assumptions rather than specific objectives. These assumptions would be structured so as to create an environment in which the student's intrinsic aspirations and potentials would be called into action by the instructional approach. The relationship between teacher and student would be altered because the classroom teacher would be assessing the assumptions by the child's performance rather than the child by his attainment of objectives.

The position that concludes this paper is that those involved in educational research might well devote some time toward the refinement of assumptions that create an instructional environment that is predominantly intrinsic. This activity would seem to represent a departure from the current emphasis in research, which appears to represent the creation of more internally consistent models of research based on the specificity of instructional objectives.

LEADERSHIP DEVELOPMENT

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During the past two summers, participants in the Leadership Conferences at the University of Maryland have been experimenting with microteaching and human factor analysis experiences interwoven with the study of ESCP themes and laboratory investigations. Such conferences have many goals. One is to develop a cadre of highly effective resource personnel for curriculum projects. Another is to encourage rational risk takers, responsible individuals who are willing to take a chance professionally when there is something of sufficient importance to be accomplished. The encouragement is an important means of stimulating innovation and new directions in science education. Other goals of such conferences include finding means of modifying teacher behavior and of helping individuals become more introspective, more insightful, more sensitive to their own talents, short comings, and impact on their students and colleagues.

Evaluation of the conferences has been done during, immediately after, and six months following the conferences. In addition, future follow-up studies are anticipated two years and five years from now to determine the impact of these conferences upon the personnel who attended and on curriculum implementation. These studies will also try to determine if the contribution of these people to science education is usual or in any way unusual.

After preliminary review of these conferences, certain aspects of microteaching, supervisory experience, and human factor analysis are being incorporated into our pre-service and in-service programs for secondary school teachers. These same techniques are being tried and have high potential value for the preparation of college level teachers through the teaching assistantship programs in academic departments.

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EDUCATIONAL RESEARCH IN THE EARTH SCIENCES

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A program to provide consultive services to graduate students and others doing educational research in the earth sciences has been established at ESCP headquarters in Boulder, Colorado. A cooperative relationship with the Laboratory of Educational Research provides one full-time graduate fellow in educational research to work on earth science research programs. Services to be provided will be individualized as much as possible, but will have mainly to do with these main areas: Suggestions for needed research for students seeking topics, experimental design suggestions before the research begins, suggestions for the collection and analysis of data, actual data analysis in problems of particular interest to ESCP, and some public exposure through publication of results in the ESCP Newsletter or NAGT Journal to stimulate additional research in the area of earth science teaching and to facilitate any implementation that might be indicated.

A complete anecdotal record of typical service rendered in one or two cases will be included to illustrate the program.

AN EVALUATION OF TWENTY-SIX NSF-FUNDED ESCP IN-SERVICE INSTITUTES

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Earth Science Curriculum Project
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The National Science Foundation (NSF) funded 26 in-service institutes during the 1968-69 school year, each of which featured the Earth Science Curriculum Project materials to some degree. The ESCP staff, in cooperation with the Laboratory of Educational Research at the University of Colorado, undertook an evaluation of these institutes to determine the effectiveness of the programs. The directors of each institute gave complete cooperation with this study, including some funding.

The Stake Model for determining a data matrix was used to determine specifically what was to be measured and how it could be accomplished. As a result of this, several evaluation instruments were constructed including questionnaires, a cognitive test, an evaluation inventory and an attitude inventory. An analysis of each instrument was completed with eventual revision and retesting of the instruments planned (Bauman, 1970).

The study involved a random sample of one-third of all the teachers in each institute, the students of those teachers, administrators and the institute director and his staff. The data were analyzed using a TALLEYEX Fortran Program and GITAP and FORTAP Programs. The data from each instrument were summarized for each institute and for the total group of institutes. The data were then analyzed using the data matrix established earlier. All questions pertaining to specific experiences within the institute program's effectiveness were analyzed.

The results indicate that the teachers, students, and administrators all felt the institutes were successful in changing teacher behavior for the better and that additional programs of this nature should be offered for teachers of earth science. Students noticed less change than the teachers and administrators. Administrators indicated that when they took time to find out, they did find a positive difference in teacher behavior. The teachers felt that the institute did provide for their needs, that it did improve their content background and methodology, and that they were better teachers in the classroom for having had the experience.

There were many areas, however, in which the investigators believed that the information received might not have reflected a true picture. These were due, in part, to the instruments themselves. They were not pretested as much as they might have been because of the lack of time. Although a 94 percent return was received on the random sample, there may have been some bias in the group not responding. Also, the instruments were rather time consuming to complete, and this may have affected some responses.

Further refinement of the instruments is currently underway. The revised instruments will be used with some new procedures in additional institutes this year. Eventually, it is hoped that the instruments and programs of analysis will be available for any director who wishes to use them, independent of ESCP.

A COMPLETE SET OF INSTRUMENTS FOR USE IN EVALUATING SCIENCE PROGRAMS

Daniel J. Bauman
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Seven instruments are offered to answer thirty-two questions relevant to science education. In response to the needs of the Earth Science Curriculum Project, the instruments were developed and item analyzed for each group relevant to the teaching of science. Teachers, pupils, administrators, and professors each have one or more instruments. Teacher effectiveness, inquiry orientation, attitudes, and values are measured. Relationships to several contemporary instruments are reported. Among the thirty-two questions for which the instruments attempt to provide answers are: Are the students able to interact with their environment? Are the facilities and equipment adequate to meet student needs? What is the level of teacher performance in cognitive science knowledge? Is the program relevant to student interest? All instruments are machine-scorable including the Q-sorts on values. Complete computer programming for scoring, integration, and analysis of data from the several sources is available upon request.

Concurrent Sessions IX

Session IXa - Curriculum Evaluation

Chairman: Ralph W. Lefler, Purdue University, Lafayette, Indiana.

1. "The Comparative Effects of Three Seventh-Grade Science Programs with Different Laboratory Materials," David R. Stronck, University of Texas, Austin, Texas.

2. "Science for Liberal Arts Majors," O. P. Puri, Clark College, Atlanta, Georgia.

3. "An Experimental Approach to the Teaching of Physical Science to Non-Science College Students," George Moriber, Michael Beitchman, Albert Kirsch, David Miller and Michael Reed, Brooklyn College, Brooklyn, New York.

4. "A Study of Varying Modes of Topical Presentation in Elementary College Biology to Determine the Effect of Advance Organizers in Knowledge Acquisition and Retention," David John Kuhn, Mankato State College, Mankato, Minnesota.

5. "The Relationship of Intellective, Personality, and Biographical Variables to Success in an Independent Study Science Course at the College Level," Michael Szabo and John F. Feldhusen, Purdue University, Lafayette, Indiana.

6. "An Analysis of Published Evaluations of BSCS," Samuel Strauss, Johns Hopkins University, Baltimore, Maryland.

THE COMPARATIVE EFFECTS OF THREE SEVENTH-GRADE SCIENCE PROGRAMS WITH DIFFERENT LABORATORY MATERIALS

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Austin, Texas

This study was designed to measure the effects of the 1967-68 science in-service program of the Archdiocese of San Francisco. This program supplied laboratory materials and instruction for 188 teachers of more than 14,000 students in 146 schools. The textbook used was the pilot edition of Patterns and Processes of Science, Laboratory Text No. 1, which provides a quantitative, laboratory-centered course for the seventh grade.

Seven schools were selected as the samples to represent the socio-economic variations of all the schools in the Archdiocese of San Francisco. The 499 seventh grade students in these schools during the academic year of 1967-68 constituted the experimental group. Their performances on the Portland Science Test were contrasted with the performances of other seventh grade students in the two control groups. The design was the Post-test Only Control Group. The first control group consisted of the 475 seventh grade students of the academic year 1966-67 in the same seven schools of the Archdiocese of San Francisco. They had a traditional general science course with little laboratory work. The second control group consisted of 351 seventh grade students of the academic year 1967-68 in six parochial schools located at a distance from the San Francisco Bay Area. Each of these schools was paired with a San Francisco school by matching the socio-economic level, the preparation of the teachers, and the use of the same text.

An analysis of the test results indicated that the seventh grade students of 1967-68 in the seven selected schools of the Archdiocese of San Francisco had significantly inferior performances in comparison with the students of the previous year. Many teachers observed that the test favored the older program by omitting quantitative questions. A highly quantitative general science course seems to present significantly less scientific facts and processes than a descriptive general science course.

Further analysis of the test results demonstrated that the seventh grade students of the experimental group had no significantly different performances in comparison with that of students in the distant schools. Without the help of an in-service program, the distant teachers spent a relatively large amount of time and money in preparing their classes. On the other hand, an efficient in-service program can suddenly introduce a radically new laboratory-centered program into all the schools of a large district.

SCIENCE FOR NON-SCIENCE MAJORS*

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A one year general science course for liberal arts majors is being developed and sponsored jointly by Clark, Morehouse, Morris Brown, and Spelman Colleges in Atlanta, Georgia. The curriculum is based upon one semester of biological science and one semester of physical science. The approach utilized is a conceptual approach and emphasizes a basic understanding of the scientific principles involved behind our macroscopic observations, with mathematics being limited to a supportive role in presenting these principles to the students. Stress is placed on the development of the sciences and what effect scientific progress has had and is continuing to have on our society. A text has been developed in physical science along with laboratory manuals in both physical science and biological science. Some laboratory exercises consisting of equipment the students should already be familiar with have also been developed for the course.

*Work supported by the U.S. Office of Education.

AN EXPERIMENTAL APPROACH TO THE TEACHING OF PHYSICAL SCIENCE TO NON-SCIENCE COLLEGE STUDENTS

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The problem of teaching science to the non-science student has long been recognized. Often students indicate that they are "afraid" of their science courses.

At Brooklyn College each year over two thousand students receive science instruction via a special physical science course that follows an historical development. The course begins with astronomy, continues with motion, heat, electricity and magnetism, light, atomic theory, and nuclear chemistry. A large number of students who have completed the one year sequence have vigorously stated that the program is not relevant to them, does not deal with subjects that may be of interest to them.

In an effort to study and evaluate student criticism a committee was formed to study the problem. It was composed of faculty and student members and, for a year, held meetings and interviewed students and faculty members.

As a consequence of the meetings it was decided to try an experimental approach to teaching the non-science student.

Last summer the experiment was carried out with forty-seven students who had enrolled in the second term of the course. Prior to the start of the term, the committee had developed a course which contained modern topics in chemistry and physics. The topics included molecular biochemistry and applications of nuclear chemistry and technology. Entire units of the regular course were eliminated so that the latter part of the term was devoted to discussing any topic of student interest. In effect most of the course was left unstructured. The students attended three hours of lecture each week and in addition they were divided into three laboratory sections meeting two hours a week. Both the lecturer and laboratory instructors informed the students that the latter part of the term would be devoted to discussing any topic they wished to discuss.

Realizing that the students may have difficulty in selecting topics, a list of topics in modern chemistry and physics covering a wide area was distributed to the students early in the term. They were told that during the next few weeks they could indicate which topic on the list [or any other topic] they would like to have discussed in class.

During the term, of the forty-seven students in the course, only six indicated that there was some topic that they were interested in studying and discussing. In the laboratory the situation was the same. When questioned about this most students stated that they did not want to "waste time" in learning new material, but preferred to devote all the available time to reviewing previously learned material. Some students indicated that they would prefer to have the instructor select the areas that should be covered.

The results of the experimental teaching program were surprising and disturbing. Many questions have now been raised: Can any course appeal to non-science students? If so, what should be the format of the course? Are the causes of lack of student interest related to an inherent lack of ability or to distasteful science experience in the lower grades?

Further study is being given to the problem and it is possible that many college science educators are interested in the science education of the non-science student.

A STUDY OF VARYING MODES OF TOPICAL PRESENTATION IN ELEMENTARY COLLEGE BIOLOGY TO DETERMINE THE EFFECT OF ADVANCE ORGANIZERS IN KNOWLEDGE ACQUISITION AND RETENTION

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The purpose of this study was to determine the effect of advance organizers, as defined by Ausubel (1963), on the acquisition and retention of meaningful verbal material. It was hypothesized that if these organizers were present in the mental structure of the learner, they would enhance the acquisition and retention of material. Two corollary studies were developed to examine the functioning of the existing mental structure without the interacting effects of the organizer.

Two approaches were utilized to study the effect of advanced organizers on the acquisition and retention process. In the first instance, the experimental group of subjects was exposed to an 800 word organizer on two occasions prior to the study of the learning passage. The comparison group was exposed to an historical passage of approximately equal length under a similar paradigm.

In the second instance, the experimental group was exposed to a brief 250 word organizer which was coupled with a careful sequencing of the material to be learned. The comparison group was exposed to an historical statement of about equivalent length and no attempt was made to sequence appropriately the material in the learning passage.

In the first corollary experiment, the information density was increased through the use of supplementary materials and the subsequent effects on information processing output were noted. In the other related study, the acquisition and retention of information was analyzed in a pattern which allowed for a flexible study time.

The measuring instruments used in this study were designed by this writer. Information store was measured by knowledge-level examinations which operated at the 1.00 level as defined by Bloom's Taxonomy (1956). Information processing was measured by instruments which functioned at higher levels of cognitive activity.

The sample involved in this study consisted of about 580 students who were enrolled in Biology 205-206, Biology for the Elementary Teachers, at Purdue University in the two years of the study. The sample included virtually all women students. An attempt was made to reduce other extraneous variables through the use of a controlled, short module of learning time of usually two to three hours in length. The data were analyzed using the statistical technique of analysis of variance.

Within the limits of the design, the following conclusions are stated:

1. The acquisition and retention of meaningful material appears to be enhanced as measured by information recall on knowledge level examination by the selective use of the organizer technique.

2. The careful sequencing of learning material coupled with the functional use of the organizer may have a positive effect on the acquisition and retention of meaningful information.

3. The ability of the individual to acquire and retain information is highly related to his analytic ability.

4. There is some evidence that organizers are particularly effective with individuals of low analytic ability. The effects of the organizer treatments with the rest of the population may vary with different organizers and the complexity of the learning situation.

5. It would appear that information processing output is related to both information store and the analytic ability of the individual.

6. There would seem to be a positive correlation between the information acquisition - retention process and the amount of study time. In both of the instances, analytic ability appears to play a major role and study time a secondary one.

THE RELATIONSHIP OF INTELLECTIVE, PERSONALITY, AND BIOGRAPHICAL VARIABLES TO SUCCESS IN AN INDEPENDENT STUDY SCIENCE COURSE AT THE COLLEGE LEVEL

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The purpose of this investigation was to assess the relationships between selected intellective, personality, and biographical variables (individual learner characteristics) and academic success in a structured independent study course (SIS) and a traditionally organized (TO) course at the college level. Both courses were freshman level biological science courses. The SIS course was taught using the audio-tutorial systems approach.

It was hypothesized that the SIS and TO courses could be discriminated on the basis of those individual learner characteristics related to success in each course.

College freshmen and sophomores (N = 630) who were enrolled in two introductory biological science courses and voluntarily completed the data forms were randomly divided into validation and cross-validation samples.

Data were correlated using a series of stepwise, buildup, linear multiple regression analysis models. These models were further modified by standardizing all variables and including interaction terms between certain personality and intellective variables as new predictions.

Analyses were carried out both within the total sample and, to control for academic ability, within three achievement level subgroups formed on the basis of a multiple regression prediction of a Ss' first semester grade index.

Individual learner characteristics from four different areas were secured: (1) from the personality area, scores on the Guilford-Zimmerman Temperament Survey (GZTS); (2) from the intellective area, high school grades in science, mathematics, social studies, and English; high school graduation rank; CEEB and SAT scores; (3) biographical information secured with a 22-item instrument developed for the study from factor analytic studies; and (4) ratings by high school counsellors of achievement-oriented personality variables. The criteria were final course grades in the SIS and TO classes.

From the analyses of the data it was concluded that prior achievement in mathematics and social studies, verbal aptitude, and the personality trait of restraint (GZTS) were significantly related to success in the SIS course.

All analyses comparing the independent study course and the traditionally organized course supported the major hypothesis.

It was found that for the total sample, prior achievement in social studies and mathematical reasoning skills were more often related to success in the SIS course; and mathematical computation skills, verbal aptitude, and prior science achievement were more often related to the criterion in the TO course.

The restraint scale (CZTS) was significantly related to success for the total group and the low achievement subgroup in both courses. Successful academic performance was independent of the score on the restraint scale for the high and middle subgroups in the SIS course, but it was highly related for these subgroups in the TO course.

Other differences which tended to support the hypothesis were noted and conclusions were drawn.

The best predictor variables were the intellective variables and the restraint scale of the GZTS. Counsellor ratings of achievement-oriented personality traits, interaction terms, and biographical predictors including sex and index of social status of the Ss were of limited value in this investigation.

This study suggests that the modified multiple regression approach is a valuable and practical tool for evaluating different instructional methods relative to discovering what are the individual learner characteristics necessary for academic success under well-specified learning conditions. When these characteristics and their interactions with modifiable aspects of instructional techniques are isolated and more clearly defined, the task of individualizing instruction within a group setting or on an individual basis will be more realistically approached.

AN ANALYSIS OF PUBLISHED EVALUATIONS OF BSCS

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Many published research reports are of poor quality, because the projects were badly planned and executed, or because the reporting was inadequate. It is probably unwise, for example, to accept the conclusions stated in any report without a critical examination to see how they were reached. I have developed a fairly rigorous set of twenty criteria by which to judge published reports, entitled "Guidelines for Analysis of Research Reports" in the December 1969 issue of The Journal of Educational Research.

The twenty criteria are: problem raised, previous work cited, objectives stated, hypotheses formulated, assumptions made, population studied, sample drawn, instruments used, design examined, procedure followed, safeguards taken, observations recorded, findings assembled, statistics interpreted, interpretations discussed, conclusions reached, limitations recognized, further work projected, improvements suggested and clarity of report.

To show how the above guidelines may be applied in a practical situation, I analyze five (more are being sought) complete published research reports of evaluations of the BSCS program. In the form of a chart, this yields a kind of analytic review entirely different from anything else known to me, for it provides a side-by-side comparison of the published papers according to each of the twenty criteria, producing a summary of the research findings as to the effectiveness of the BSCS program, and a picture of the strong and weak points of each evaluation study. The paper to be read at the NARST meeting consists of this review chart.

The values of this procedure are that it (1) furnishes a technique for reviewing and summarizing the research studies in almost any scholarly field, (2) demonstrates how reports and papers about research may be judged and evaluated, and (3) provides a practical guide for planning and carrying out research projects.

Session IXb - Models for Curriculum Evaluation in Science

Chairman: Robert R. Buell, University of Toledo, Toledo, Ohio.

1. "A Model for Analyzing and Comparing Instructional Strategies and Programs," Robert L. Uffelman, University of Delaware, Newark, Delaware.

2. "Implicit and Explicit Assumptions Underlying Science Curricula, An Aspect of Curriculum Evaluation," Hulda Grobman, New York University, New York, New York.

3. "Programed Instructional Materials in Science for Local School Use -- An Approach to Their Evaluation," Seth F. Wohl, Teachers College, Columbia University, New York, New York.

4. "Inductive Inference in Scientific Thinking," Stanley B. Brown and L. Barbara Brown, California State Polytechnic College, San Luis Obispo, California.

5. "A Vibrating Molecular Model System for Visualizing Molecular Motions as Induced by the Absorption of Infrared Radiation," Joseph S. Schmuckler, Temple University, Philadelphia, Pennsylvania.

A MODEL FOR ANALYZING AND COMPARING INSTRUCTIONAL STRATEGIES AND PROGRAMS

Robert L. Uffelman
University of Delaware
Newark, Delaware

Many changes are being made in curricula for science at all levels. Teams of specialists in subject matter, learning, and instruction have joined together to develop educational packages that are quite different from what the schools have been using. A comprehensive model is needed for analyzing these new programs and for judging their suitablitiy. Since available models were inadequate, the purpose of this study was to develop one that could be used for comparing, synthesizing, and evaluating the recommended practices and for research and development of new programs.

A survey of standard research references, publications of curriculum development organizations, and other relevant literature was conducted. A model was proposed and tested by pre-service teachers for developing daily lesson plans, by in-service teachers for revising instructional programs, and by graduate students for analyzing and comparing educational research reports. Modifications were made and re-tested empirically over a two-year period.

Instructional strategies and programs can be categorized according to observable characteristics and these categories can be subsumed under headings recommended by educational leaders. These are (1) Rationale, (2) Content, (3) Methods, (4) Materials, and (5) Evaluation. However, there is no common agreement on style, format or sequence to be followed in specifying these elements for others.

These categories contain subsets of principles and practices that assist in comparing proposed programs. Rationale can be divided into Objectives and Learning Theory. These groupings permit delineation of goals and identify the underlying psychological theories without stating preference for any particular viewpoint. Content is divided into substance and process to identify the major emphases of the programs. The methods category permits identification of instructional patterns or the newer experimentalist views. Materials are divided into two standard categories, since their classification is determined by their use and is not inherent in the objects themselves. Three assessment categories are recommended to permit broader based evaluation criteria.

As one uses the model, he discovers that one program advocates one type of objective and learning, while another suggests another learning theory and instructional strategies to meet the same objective.

Thus programs are compared by identifying the appropriate cell under each category that describes the recommended practice and then determines the recommended pattern for the program or instructional strategy. Proposed programs can identify the desired viewpoint in each category and develop appropriate statements, instructional strategies and materials to achieve the desired results. Research studies are analyzed in a similar manner and results and omissions identified.

Figure 1

A Model for Analyzing and Comparing Instructional

Strategies and Programs

I. RATIONALE		II. CONTENT	III. METHODS		IV. MATERIALS	V. EVALUATION
A. OBJECTIVES	B. LEARNING THEORY	C. SUBJECT MATTER	D. TYPE OF ACTIVITY	E. CLASSROOM INTERACTION	F. TYPE OF MATERIALS	G. ASSESSMENT
Cognitive: Factual	Conditioning	Substance	Directive	Giving Information	Concrete	Learner
Cognitive: Reasoning	Cognitive Restructuring	Process	Heuristic	Questioning	Vicarious	Instructor
Psychomotor Skills	Identification			Evaluative Feedback		Program
Affective Domain				Response		

Judgments indicate this model is appropriate for comparing educational packages and for planning instructional programs acceptable to a wide range of educational philosophies, beliefs, and practices. Thus, educators can make decisions based on comparable evidence rather than using intuitive judgments about the adequacy of new materials.

IMPLICIT AND EXPLICIT ASSUMPTIONS UNDERLYING SCIENCE CURRICULA, AN ASPECT OF CURRICULUM EVALUATION

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New York, New York

Today, for most curricula in science, there is usually some statement of objectives. Such statements may be made in general or in specific terms, and the evaluation of materials is generally focused on them. However, often overlooked are two facets of curriculum.

The first concerns the extent to which the curriculum contributes to general school objectives, to the development of broad skills and attitudes that are part of the school's general education responsibility. This includes the values the school hopes to develop as well as such general academic skills as communication skills, increased working vocabulary, ability to follow written instructions, and ability to locate and use reference materials. The fact that these are not identified with a particular curriculum in science generally means that attention is not directed towards them. As a result, the curriculum may be hampering rather than encouraging their realization.

Second, all curricula reflect value judgments about the individual and his role in society; all reflect a philosophy of education, including assumptions about the purpose of education, the role of education in society today, the definition of a good society, and a theory of learning. Such philosophies, theories, and value judgments may be implicit rather than stated, but they are present in all curricula - including all curricula in science - and they are basic to the curricula. The fact is that these unstated assumptions may have greater impact on the student than anything else taught in the curriculum.

This paper deals with the kinds of questions related to learning, to the philosophy of education, and to the general education objectives that may be used to analyze science curricula. Such questions include:

> How do students learn most effectively? Do all students learn best in the same way?
>
> Will training in one area be transferred automatically to other areas? If not, under what circumstances will such transfer occur?
>
> Should learning go from the abstract to the concrete or from the concrete to the abstract?
>
> Should learning be sequential and pyramided on previous learning?

What level or type of cognitive skills enhance retention or learning and increase ability to use present learning in later, different tasks?

What constitutes progress?

There are hundreds of such questions that are germane to science curricula and that reflect the assumptions underlying these curricula. The review of curricula with such questions in mind constitutes a kind of content analysis to which all curricula should be subjected, so that rational decisions can be made concerning their appropriateness for the student and the school where they are being considered.

PROGRAMED INSTRUCTIONAL MATERIALS IN SCIENCE FOR LOCAL SCHOOL USE

AN APPROACH TO THEIR EVALUATION

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The principal purpose of this study was the production of sets of procedures known as *guidelines* that could be placed in faculty hands for implementing the use of programed instructional materials with science curricula on the local school level.

The need for *guidelines* was evidenced by documented underutilization of existing self-instructional materials in science at a time of increasing emphasis on individualization. Such *guidelines* specifically applicable to science education were absent from the literature.

How can programed instructional materials in science be evaluated by science teachers and supervisors for local use?

GUIDELINES[1] were developed the same way as programed instruction--empirically, through experiences of local faculty teams in working with six aspects of the problem: (1) locating available programed materials, (2) determining criteria for their selection, (3) evolving rapid procedures for locally revalidating them with small student samples, (4) simplified data procedures from these initial tryouts, (5) generating the GUIDELINES, and (6) evolving suggestions for their implementation.

Use of standard bibliographies helped locate several hundred commercially available programed science materials.[2,3] Observable "internal" and reportable "external" criteria were listed for 100 programs, and 13 of these were selected as potentially applicable to the local curriculum if revalidated.[4] Revalidation with only 3 students per class became feasible under multiple class replication and teacher aptitude ratings correlated with standardized science achievement scores. A six-step "learning cycle" procedure was observed for students. GUIDELINES were evolved from these findings and three principal concerns of local program users were identified: (1) need for a resource person helping teachers work more effectively with programed materials, (2) ready evaluation of individual learning achievement, and (3) relevance of selected self-instructional units to the local science curriculum.

It is feasible to develop guidelines empirically by using few students in local preliminary "revalidation" tryouts with programed science materials. Effectiveness appears contingent upon coordinating activities of a resource person to standardize selection and individualized study, to allocate materials, and to insure adequate implementation of revalidated programs.

These GUIDELINES are uniquely different from earlier attempts by its empirical base, wider range of administrative, curricular, and implementation provisions, and its detailed operational specifications for programed individualized study.

Flexible design suggests broad applicability of these GUIDELINES beyond science to other desciplines in education and industry.

FOOTNOTES

[1]*The guidelines appear as an appendix in the dissertation:* "An Approach to the Evaluation of Programed Instructional Materials in Science for Local School Use" by Seth F. Wohl, Teachers College, Columbia University, 1968, pp. 357-389. *The study is available from University Microfilms, Ann Arbor, Michigan. Publ. No. 69-8091.* *(49 wds.)*

A mimeographed copy of the guidelines (©1969) alone under the title: "Guidelines for Implementing Programed Instructional Materials in Science" *will be made available upon receipt in advance of $1.00 to the author at Box 129, Teachers College, Columbia University, New York, New York 10027.* *(41 wds.)*

[2]Carl H. Hendershot, Programed Learning: A Bibliography of Programs and Presentation Devices, 4th Ed., published by Carl H. Hendershot, Bay City, Michigan, 1967. *(23 wds.)*

[3]Programed Instruction Guide, Newburyport, Massachusetts: Entelek, Incorporated, 1967 (computer-compiled). *(10 wds.)*

[4]Joint Committee on Programed Instruction and Teaching Machines, "Criteria for Assesing Programed Instructional Materials: 1962 Interim Report," Audiovisual Instruction, Vol. 8, No. 2 (February 1963), pp. 84-89. *(28 wds.)*

INDUCTIVE INFERENCE IN SCIENTIFIC THINKING

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This consideration focuses directly on inference in a philosophical - psychological frame of reference and scientific thinking - applicable at the junior high school general science students level. A review of scientific investigation techniques support the notion that the simplest and most direct approach to the solution of a scientific problem is a psychological perceptiveness to the facts (observation) and then deducing appropriate statements (inferences) from them.

Experimental		Observable		Ideas		Explanations
Background →	Exposure →	Facts →	Generation Of →	Intuitive-Thinking →	Tentative Results →	Speculation
(Investigator		Natural-Phenomena		Premises		Predictions
				$\boxed{\text{Inferences}}$		

INITIAL PSYCHOLOGICAL - PHILOSOPHICAL PHASE IN SCIENTIFIC INVESTIGATIONS

The cookbook approach in attempting to solve junior high school general science problems relegates the student to a technician .... Step 1, 2, 3, and so on. The point in this consideration of inference in scientific investigation is to attempt to discuss the role that inference plays in what scientists do -- and hence important in general science laboratory experimentation today. Note that modern scientists use many such words as . . . deduce, imagine, induce, inference, inquire, intuition, perceive, predict, speculate, etc.

There are a number of ways of generating inferences, but the scientist normally relies on logic. Logic deals with a non-empirical truth relationship between a premise and a conclusion. If the premise is a law or hypothesis and if the relation between premise and conclusion is logically true, then the conclusion must be an inference.

To infer is to pass from one proposition, statement or judgment considered as true to another whose truth is believed to follow from that of the former.

A scientist is interested in making statements about nature which he can defend as true. The scientist's criterion for recognizing and defending true statements is observation. He must see if what the statement asserts actually corroborates with the findings in his observation. A statement confirmed by observation is said to be empirically true. A scientist's most useful empirically true statements about nature are also universal statements. A statement is universal if it is true for all times and all places in the universe.

Inferences are important to science in three ways. First, when empirically confirmed, an inference may lead to new laws or hypotheses. Second, when empirically confirmed, an inference gives more confidence in the law or hypothesis from which it was generated. Third, if an inference is found empirically false, the law or hypothesis from which it was generated must be partially or completely false.

We now encounter the problem of how an inference is obtained from a law or hypothesis. Since scientists accept only empirical truth, logical truth must be tested and shown by experiment to be empirically true. When the logic form is deductive--from a general statement to a specific conclusion--the conclusion is called a deductive inference. When the logic form is inductive--from a specific statement to a general conclusion--the conclusion is called an inductive inference.

Selected examples of inductive inference described and interpreted follow: Sir Isaac Newton's Law of Universal Gravitation, Albert Einstein's Basic Thinking in Relativistic Mechanics, a blind man's interpretation of an elephant, Percival Lowell and Clyde W. Tombaugh's investigations culminating in confirming the planet Pluto and nuclear particle symmetry experiments leading to the discovery of a Nutrino.

A VIBRATING MOLECULAR MODEL SYSTEM FOR VISUALIZING MOLECULAR MOTIONS AS INDUCED BY THE ABSORPTION OF INFRARED RADIATION

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A study involving the development of a mechanical model has been carried out which will illustrate the types of molecular vibrations which are induced when simple molecules absorb electromagnetic radiation of certain specific frequencies.

The investigation is based on the assumption that a better understanding of molecular vibrations (some of which are difficult to visualize) and their relationship to the frequency of the initiating radiation, can be obtained by a working mechanical model, than by a verbal or written description of such phenomena.

Plastic balls held together by metal springs have been used as the macroscopic analogs of atoms and chemical bonds, respectively. The resulting molecular models have been permitted to float on a water surface in a specifically constructed paddle tank. A mechanical device has been used to 'irradiate' a given molecular model with water waves of controlled, specific frequency. These water waves are used as the mechanical analogs of electromagnetic waves. It has been demonstrated that when a molecular model is irradiated with water waves of certain frequencies that certain modes of vibration are induced in the model, the mode and frequency of the vibration depending only on the mass of the balls, the force constant of the springs connecting them, and on the frequency of the water waves. It has been further demonstrated that, in this respect, the molecular models behave in an analogous manner to real molecules when they are irradiated with electromagnetic waves of a certain frequency. The behavior of real molecules interacting with electromagnetic waves depends only on the mass of the constituent atoms and on the force constant of the chemical bonds. The scientific validity of the behavior of a molecular model of carbon dioxide, CO_2, has been demonstrated by showing that the ratios of the frequencies, and the ratios of the force constants for a given mode of vibration of the model, are identical to within experimental error, with the frequency and force constant ratios for the same modes and vibrations of molecular carbon dioxide.

The basic conceptual mathematics for treating both the model and the molecular systems has been developed. A guide as to how the material could be used by a high school teacher of physics or chemistry has been presented.

Session IXc - Symposium: SCIS and the Disadvantaged: A Report from the Field

Chairman: Herbert D. Thier, Science Curriculum Improvement Study, University of California, Berkeley, California.

Participants: Sister Mary Ivo Miller, Fisher Scientific Company

Mary Budd Rowe, Teachers College, Columbia University, New York, New York.

Reuben Pierce, Department of Science, Public Schools, District of Columbia.

Seymour Sitkoff, Elementary Science Supervisor, Los Angeles City Schools, Los Angeles, California.

Sylvester Webb, Science Curriculum Improvement Study, University of California, Berkeley, California.

SYMPOSIUM ABSTRACT

SCIS AND THE DISADVANTAGED: A REPORT FROM THE FIELD

National interest in and concern about the education of disadvantaged children has increased sharply in recent years. Many studies and major federal programs have indicated the inadequacy of usual educational programs for these children, ranging all the way from the lack of relevancy found in so many of the traditional reading programs to the concern about the capability of middle class white teachers to interact with black disadvantaged children. The problems of educating the disadvantaged are complex and are not easily solved. Rather than propose another panacea or short-term answer that has to be abandoned when it proves to have little long-term value, the purpose of the symposium is to present evidence from the field regarding the use of the Science Curriculum Improvement Study program with disadvantaged children.

From extensive trials across the country, both in urban and rural areas, evidence is available which shows that the program provides meaningful science experiences for the disadvantaged child. In addition, SCIS is valuable as an early aid to overall language development and may very well help to reduce the alienation the disadvantaged child feels towards the school as an institution. The individuals reporting at the symposium have been directly involved in the implementation and actual use of the program in various urban and one interesting rural area. Their reports are intended to present how one gets such a program started, some important considerations relative to the training of teachers for such a program and beginning observations and evidence relative to the effectiveness of the program in meeting the educational needs of disadvantaged elementary school children.

Time will be allocated for a discussion after the presentations, and it is hoped that those interested in this important area of education will come, question and analyze the presentations, present some of their own experiences, and so help to increase the knowledge and understanding of all about this most challenging educational problem. It is expected that during the presentations and discussions, a number of significant problems which could form the basis for important research studies will be identified.

GENERAL SESSION C

Presiding: Paul DeHart Hurd, Stanford University, Palo Alto, California

Speaker: Robert Livingston, University of California at San Diego

"A Proposed Curriculum for Middle School Science Education"

Concurrent Session X

Session Xa - Career Development of Science Teachers

Chairman: Hans O. Anderson, Indiana University, Bloomington, Indiana.

1. "Career Development of Science Teachers," Eugene C. Lee, Emory University, Atlanta, Georgia.

2. "An Analysis of the Career Development and Education of Astronomers in the United States," Richard Berendzen, Boston University, Boston, Massachusetts.

3. "Correlates of Science Teacher Retention," Matthew H. Bruce, Temple University, Philadelphia, Pennsylvania.

4. "A Cross-National Study of Relationships Between Professional Variables of Secondary Teacher Education Students," John M. Vergiels, The University of Nevada (Las Vegas), Las Vegas, Nevada.

CAREER DEVELOPMENT OF SCIENCE TEACHERS

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The purpose of this research project was to verify or modify, and extend previous work in the area of the career development patterns of science teachers.

Data for conducting this research was made available from Project TALENT. Using seven career groups (Mathematician, Physical Scientist, Biologist, Math Teacher, Science Teacher, Secondary Teacher, Engineer) and twenty-two factors derived from the original test battery, a twenty-two variable seven-group discriminant analysis was performed for the five-year follow-up data on 5,114 males from the 1960 high school graduating class.

Group deviations from the grand means on each of the 22 factors for the seven career groups indicated that on the sociability factor the highest group was secondary school teachers followed by science teachers. The science groups were either near or below the mean. On the science interest factor, the science teachers were on the positive side of the mean while other secondary teachers were highly negative.

Six discriminant functions were derived from the seven groups. The three significant (.001) discriminant functions were plotted as follows: I vs. II, I vs. III, and II vs. III.

It was found that discriminant function I separated science teachers from the mathematicians and physical scientists (the positive end of this function tends toward sociability, the negative end tends toward mathematical ability). Discriminant function II provided separation among the biologists, science teachers, engineers, and math teachers who were closely grouped in discriminant function I. Biologists scored high and mathematicians low on discriminant function II (orientation toward verbal knowledge). Plotting discriminant function I vs. II provided additional separation between physical scientists and mathematicians with mathematicians showing higher weighting on discriminant function II (verbal knowledge high positive factor). Plotting discriminant function II vs. III showed math teachers at one end of discriminant function II and biologists at the other end, mathematicians high on discriminant function III, and engineers close to the negative end with the other groups in between.

AN ANALYSIS OF THE CAREER DEVELOPMENT AND EDUCATION OF ASTRONOMERS IN THE UNITED STATES

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Boston, Massachusetts

An extensive study has recently been conducted on the education, vocational interests, pedagogical viewpoints, and employment of astronomers in the U.S. In the present report, some of the findings are noted on astronomers' career development, undergraduate preparation, and opinions on education.

Information in this study came from the following sources: unpublished data from the National Science Foundation's National Register of Scientific and Technical Personnel and from the National Academy of Sciences' Doctorate Files; from the U.S. Office of Education; from the National Aeronautics and Space Administration; from the chairmen of about 90% of the astronomy departments in the U.S.; from other studies; and from a questionnaire sent in this study.

That questionnaire was sent to every member of the American Astronomical Society, which contains most of the professional astronomers in the nation. The 1103 forms that were returned include replies from about two-thirds of the U.S. astronomers that belonged to the AAS. This sample is statistically homogeneous with government compilations of U.S. astronomers and with U.S. membership in international astronomical societies.

Respondents are classified according to various attributes; for instance, astronomers are subgrouped according to primary professional activity, alma maters, degree fields, age, current geographic location, and so on. One such segregating scheme is by relative productivity of research papers. The productivity index used here compares a respondent's total number of published papers in professional astronomical and astrophysical journals with that of American astronomers of the same age who hold Ph.D.'s in astronomy. This index provides an assessment of the education and attitudes that are characteristic of scientists of different research productivities in astronomy, under the imperfect (but analyzed) assumption that prolificness in publication indicates prolificness in research.

The data in this study were analyzed using DATA-TEXT computer language. The null hypothesis is framed tacitly for diverse issues and tested with the t, F, and chi-square statistics; correlation coefficients and coefficients of predictive association are calculated and discussed.

Detailed information is provided for subgroups of U.S. astronomers on three important aspects of career choice: motivations for first interest in astronomy; ages of first interest; and year-by-year development of career interests. Complex, but identifiable, schemes emerge in the vocational evolutions of the different subgroups.

Likewise, information is provided for the subgroups on high school, undergraduate, and graduate education; on self assessments of their education; on their evaluations of college astronomy progress, and on their views for what would constitute ideal educational preparation for various types of proto-astronomers.

This study provides information that hopefully will be helpful to vocational counselors in their advising about careers in astronomy and to educators in their planning of coordinated education programs at all levels in astronomy.

CORRELATES OF SCIENCE TEACHER RETENTION

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Objectives: (1) To search for patterns of personal characteristics that relate to the tendency to leave teaching during the first few years; and (2) if these are found, to determine whether a pattern exists for science teachers which is different from that for secondary teachers generally.

Teachers in the first four years of teaching who have been associated with the secondary intern teaching program at Temple University during the years 1964-67 were analyzed.

Two categories of teachers were studied. They were those who left teaching for reasons other than those which could reasonably be assumed to involve the intent to return at some future date (e.g., married women who became pregnant were excluded from this group) and those who remained in teaching to the date at which the study was terminated. Subgroups were formed from each category to include only science teachers. These groups were compared on several indices of personality as measured by the Minnesota Multiphasic Personality Inventory and on some general characteristics such as sex, age at entrance, and academic performance as undergraduates. The Mann-Whitney 'U' test or the chi-square test was used as appropriate to the data and purpose.

Several indices were found to discriminate significantly (α=.05 or less) between the groups. Certain patterns of combined indices were found to describe persons who were likely to leave teaching during the early years. These indices and patterns were essentially the same for science teachers as for secondary teachers generally.

Some personality patterns detectable in advance do tend to predict early withdrawal from teaching. While these do not operate in isolation but are part of a more complex picture, if they can be demonstrated through further study to be general rather than local they provide clues both for teacher selection and for the guidance of teachers in their early years toward the end of increasing the level of retention. Combining these findings with those related to teacher success could lead to more effective application of resources in teacher education.

A CROSS-NATIONAL STUDY OF RELATIONSHIPS BETWEEN PROFESSIONAL VARIABLES OF SECONDARY TEACHER EDUCATION STUDENTS

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Previously, a cross-national study of the characteristics of biology teachers in United Kingdom and United States was reported at the NARST meeting (Ten Hoeve, 1966). The present study comprises the whole of the secondary education majors in that sample.

The purpose of this study was to examine the relationships between professional variables for final year secondary education majors in Great Britain and the United States. The data were gathered in a cross-national study by Dickson, et al., conducted in 1964 and reported in 1965. Dickson administered tests to approximately 4,700 pre-service teacher education students in the four areas of: (1) teacher attitude and personality characteristics, (2) general education preparation, (3) professional education knowledge, and (4) general intelligence. Of the above 4,700 students tested, 866 were in their final year and these comprised the students for this study. For the purpose of this study, the students were divided into four groups: (1) England and Wales training college students, (2) England university students, (3) Scotland university students, and (4) United States college and university students.

The tests used in this study were the Minnesota Teacher Attitude Inventory (MTAI), the Ryans Teacher Characteristics Schedule (RTCS), and the Teacher Education Examination Program (TEEP). Each of these tests yielded scores which gave the investigator an indication of what learning had taken place previously by the students in the different programs. The MTAI yielded a single score, the RTCS nine scores, and the TEEP three scores (Child Development & Educational Psychology, Guidance and Measurement, and Instructional Methods). Central to the study were the Pearson Product-Moment correlation coefficients found between the twelve variables (RTCS & TEEP) and the MTAI. The MTAI was assumed to be the indicator of the future teacher's ability to get along with pupils in the classroom. Hence, the ability to get along harmoniously could be indicated by corresponding values on the RTCS and the TEEP as demonstrated by correlation coefficients. This yielded twelve correlation coefficients for each of the populations studied, or a total of forty-eight correlations for the four different teacher education programs. In addition, matrices of correlations between all scores were analyzed for each of the four programs.

The conclusions for this study were:

1. Attitudes towards students (MTAI) related more closely with professional measures (TEEP) for English training college students and United States students than for England university students and Scotland university students.

2. Attitudes toward students (MTAI) related more closely with characteristics (RTCS) for English training college students and United States students than for England university students and Scotland university students.

3. The apparent lack of success to achieve more positive relationships between professional variables for England and Scotland university students was founded in the in-depth concentrated three years of academic training preceding the single year of professional training. The very brief period of professional training did not present the England and Scotland university students with the opportunity to develop the proper relationships between the characteristics, attitudes, and knowledge commonly accepted as positive factors for classroom teachers.

4. The original Dickson study supported the concept that the United Kingdom students were more academically oriented and the United States students were more professionally oriented. This present study demonstrated that relationships cut across national boundaries and show similarities and dissimilarities directly related to the kinds of teacher training, viz., the three and four year parallel academic, professional and general course sequence (England training college and United States college and university) versus the three years academic training followed by a single year of professional training (England university and Scotland university).

5. All four student groups had moderate relationships for those items of the RTCS which indicated favorable opinions of others, with the parallel program students having higher relationships than the non-parallel program students. However, the relationships between educational viewpoints and attitudes toward students were not related in the same pattern mentioned above. This disclosed a conflict between how a teacher education student reacts objectively and affectively toward students, but the educational viewpoint still maintains a traditional emphasis rather than a modern, permissive, child-centered viewpoint.

Session Xb - Symposium: Teacher-Pupil Interaction

Chairman: Manert Kennedy, Biological Sciences Curriculum Study, Boulder, Colorado.

Participants: Jal S. Parakh, Western Washington State College, Bellingham, Washington.

LeVon Balzer, Western Washington State College, Bellingham, Washington.

Thomas P. Evans, Oregon State University, Corvallis, Oregon.

Session Xc - Symposium: Science and the Child as Determinants of an Elementary School Science Program

Chairman: John R. Pancella, Montgomery County (Maryland) Public Schools

Participants: Darrell G. Phillips, University of Iowa, Iowa City, Iowa.

Paul Westmeyer, Florida State University, Tallahassee, Florida.

Charles C. Matthews, Florida State University, Tallahassee, Florida.

Ronald G. Good, Florida State University, Tallahassee, Florida.

Martha G. Camp, Florida State University, Tallahassee, Florida.

ANNUAL LUNCHEON

Presiding: N. E. Bingham, University of Florida, Gainesville, Florida

Speaker: Willard J. Jacobson, Teachers College, Columbia University

"Approaches to Science Education Research: Analysis and Criticism."